FOR MANUFACTURERS

WORKSHOP RECEIPTS

FOURTH · SERIES

WATERPROOFING.	EVAPORATING.
FASHING & SILVERING	FILTERING.
EMBALMING & PRESERVING	PENETRATING & MACERATING
LEATHER POLISHES.	ELECTROTYPING.
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PHOTOGRAPHY &c. &c.

SCIENTIFIC AMATEURS.

WORKSHOP RECEIPTS.

(FOURTH SERIES.)

BY

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PREFACE.

Since the appearance of the original volume of 'Workshop Receipts,' the Publishers have been continually receiving inquiries for books or articles on a variety of subjects not possessing in themselves sufficient importance to warrant their being described in special treatises, yet interesting to a great number of readers, and collectively worthy of publication in book form. The result of these inquiries was a determination to issue a series of volumes bearing the same title—'Workshop Receipts'—devoting each Series to a special class of subjects. Thus the Second Series dealt with operations and industries having a more or less Chemical basis; while the Third Series embraced Metallurgical and Electrical matters. Both attracted much attention, and have been in every way successful. There still remained a number of subjects of equal utility and of every-day application, connected with Handicrafts and Mechanical trades, coming within the scope of all intelligent persons, and certainly not less interesting than the contents of previous volumes. These have been gathered into the Present (Fourth) Series. While each Series possesses its own special value, the utility of the four volumes has been completed by furnishing the fourth with a General Index to the whole set. From the great range of subjects dealt with and the facility thus afforded for reference, the four series of 'Workshop Receipts' may be said to constitute in themselves a well-stored library of technical information such as no other publication affords. The descriptions and instructions are given in plain language, aided by diagrams where necessary; technicalities are explained, and every care has been taken to check the quantities, and to make the index a real guide to the contents.

C. G. Warnford Lock.

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WORKSHOP RECEIPTS.

FOURTH SERIES.

WATERPROOFING.—The art of rendering fabrics impervious to moisture has attained considerable importance, especially in the case of clothing materials. A few simple processes are briefly described in the First Series of 'Workshop Receipts,' but many others are now in vogue, some conducted on an industrial scale.

Rubber Goods.—Since supplies of indiarubber have been regular and abundant, that useful vegetable secretion has been very largely employed as a waterproofing agent for wearing apparel. The crude rubber, which is received at rubber works in the condition in which it is imported, varies greatly in appearance and quality, as well as in the amount of impurities it contains, and which must be removed before it can be manufactured.

The preliminary processes, therefore, to which the crude material is subjected, have for their object this cleansing of the rubber from impurities, and at the same time the softening of it, and its reduction to a form in which it is best fitted for subsequent operations. (1) The crude material is introduced into a vat or tank with water, and boiled by throwing in free steam. This operation, which has the effect of softening the crude masses, is sometimes carried on in the open air, but in other works within some part of the building. Some makers find it sufficient to soak the crude rubber in water at a temperature not higher than 120° F. (49° C.). (2) When thus softened, the masses of rubber are passed between powerful rollers, the surfaces of which are indented with flat, square indentations, while a stream or jets of water flow upon the rubber from a perforated pipe above. By this operation the rubber is flattened out into a thin sheet, and more or less torn and disintegrated, while the water works out the foreign substances, dirt and impurities, which the boiling has failed to remove. This process is repeated until the mass is thoroughly cleansed. The result is the production of a thin crumpled sheet, full of holes, which is then hung up in a room warmed by hot air to dry. (3) The rubber thus washed and cleansed is introduced into the "masticator," which consists of a strong cylindrical box, containing a stout deeply-fluted iron drum, which revolves within the box; steam is introduced into the interior of the drum, and a current of water is kept running between the drum and the cylinder. It is then introduced dry into another similar "masticator," the flutings of the drum of which are made sharp and chisel-shaped. The rubber is here torn to pieces, rendered homogeneous, and the last traces of air or water are expelled. At some works this process of "mastication" is omitted. (4) If it be desired to cut up the rubber into sheets, &c., the rubber thus prepared is made into blocks of the requisite size by compression in a strong screw-press iron box, the inside of which is smeared with French chalk to prevent sticking, and the sides

of which are hollow and filled with steam. A uniform block is thus obtained, which when cold or frozen can be cut into thin sheets or smaller blocks as may be desired. (5) When it is intended to prepare the rubber for the process of "vulcanisation," the vulcanising material is either kneaded with the rubber in a masticator, or by means of mixing rollers heated by steam and kept for the purpose. In either instance it is in the form of the rough sheets above described that the rubber is introduced, and there is a shallow tray beneath to catch such of the material as falls through. The vulcanising material consists generally of finely-sifted flowers of sulphur, together with colouring powders such as lampblack, zinc oxide, or antimony sulphide (orange). These are thoroughly incorporated with the rubber in the apparatus used. (6) After this stage of preparation, the Goodyear or American process, and the Hancock or English process diverge. (*a*) By the Goodyear process, the rubber thus prepared is rolled out into sheets by causing it to pass between strong iron rollers heated by steam, in what is known as the "calendering" machine, and these sheets may be subsequently manipulated for the construction from them of various kinds of articles. As the sheet passes from between the rollers it is received upon linen, and the linen and indiarubber sheets are rolled up together upon a roller. (*b*) In the Hancock process some solvent is used to soften the rubber and convert it into a thick paste. The solvent now universally used is that product of the fractional distillation of light tar oil known in the trade as "solvent naphtha." The solution is sometimes effected in a close cylinder, where the rubber and naphtha are, by an arrangement provided within the cylinder, wrought up together, and from which the pasty product is drawn off by means of a tap below. The paste is received into iron pots provided with covers, in which pots it can be reduced, by hand mixing with more naphtha, to any condition of liquidity that may be desired. In other works the solution is effected in another way. The rubber, calendered out into a thin sheet, is passed between a pair of hot rollers into an open vessel containing naphtha, by the side of which vessel a workman sits and presses down the sheet, softened by the heat, into the naphtha. When rubber enough has thus been put in, the vessel is covered up and set aside for the completion of the solvent action. In other works the rubber is simply mixed with the naphtha with a spade. In order to make the thick paste into a sheet, what is termed a "spreading machine" is used. This consists of a table formed of a hollow steam-chest, along, but not touching, which a sheet of linen previously sized is rolled off from a roller at the spreading end to a roller at the farther end, and from this to other rollers underneath. By an arrangement devised for the purpose, the softened rubber or thick paste is spread in a thin layer on this linen as it passes to the top of the steam-chest; and the rubber thus laid on is carried upon the linen as if it had been painted on it. As the sheet passes slowly along the top of the steam-chest, the heat causes the solvent to volatilise. This operation is repeated until the required thickness of rubber is obtained. It is conducted in a room where many similar machines are in use at the same time. The rubber is then stripped from the linen by rolling each off in different directions upon different rollers, with the aid of water. As the rubber is rolled off, it is evenly coated with a wash of French chalk, to prevent sticking, and the roll being bound round with a wet cloth bandage, is ready for the "vulcaniser." In making rubber tubing, the solution of rubber above mentioned, is used to smear the edges of the strips of rubber which are to be made to cohere; the solution is also used in the manufacture of mixed linen and rubber tubing, and also in the joining of surfaces of material in the manufacture of articles of dress, &c.

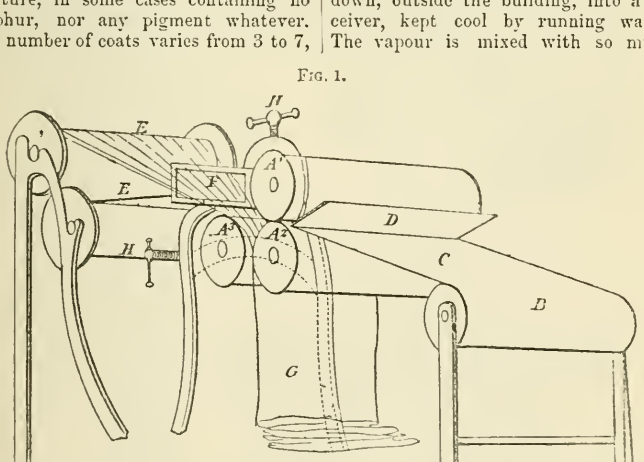
Spreading.—Reference may now be made in greater detail to the treat-

ment of fabrics which are to be "proofed" by spreading. This consists in passing them through a pair of calenders, with the object of pressing down knots, and giving a smooth and even surface; after this, they are passed over a steam-chest, to expel moisture, when they are ready to receive the first coat. This is usually a different mixture from the bulk of the proofing, and is called a "sticking-coat," its object being to secure adhesion between the fabric and rubber; it is generally incorporated with colouring pigments, white or black, so as not to allow the general mixture to show through the cloth, or alter its appearance. A little zinc oxide, or whiting, is used for white or light-coloured goods; Frankfort and other blacks are used for dark goods. The coats, as applied, are dried by passing over a steam-chest, when the fabric is again brought to the front of the machine for another coat, and so on. Some descriptions of goods have a finishing coat of better quality or mixture, in some cases containing no sulphur, nor any pigment whatever. The number of coats varies from 3 to 7, according to the class of goods and the weight of material which is to be put on.

Machines are now employed which work on the continuous principle; but as they require more space, so as to allow each coat to dry in time to receive another, it is not certain that there is much gain in using them.

Recovering Naphtha.—Methods have been devised for collecting the naphtha vapour and condensing it; the principal objections to these arrangements are that they interfere with the workman's ability to see his work as it passes over the steam-chest, and do not allow the naphtha itself to pass off so completely, owing to the partial obstruction. The enormous quantities of naphtha which are dissipated in the spreading-rooms of some of the largest establishments, afford sufficient evidence of the want of some suitable means for this object. One plan which has been used, and which certainly does collect some of the naphtha, consists of a rectangular iron hood, of such dimensions as to cover the steam-chest, or the greater part of it, and raised towards the middle, where it opens into a zinc chimney or flue, and passes down, outside the building, into a receiver, kept cool by running water. The vapour is mixed with so much air, which passes away charged with the naphtha vapour, that it is only possible to collect a very small proportion of the latter. Bruce Warren's

FIG. 1.



method has been used with success. Its peculiarity lies in collecting the naphtha vapour by indiarubber, which is capable of abstracting solvent vapours from air charged with them. The air, loaded with the vapour, is made to traverse a series of trays containing laminated rubber, which is required either for solution or for dough; or the naphtha may be recovered by distillation, and the rubber be used over again.

Fig. 1 shows an arrangement for spreading and doubling at one operation. B is a roll of fabric, passing under a knife D, in the front of which is placed, along the whole width of C, a roll of dough or cement; E, 2 beams of yarn, warped in the usual manner, passing through the reed F, and on to the adhesive surface of C. The pressure regulated by H on the rollers A^1 A^2 A^3 firmly unites the whole into one fabric G. Instead of the yarns, a woven fabric or fleece may be employed, as on B. The rollers are hollow, so as to admit steam.

FIG. 2.

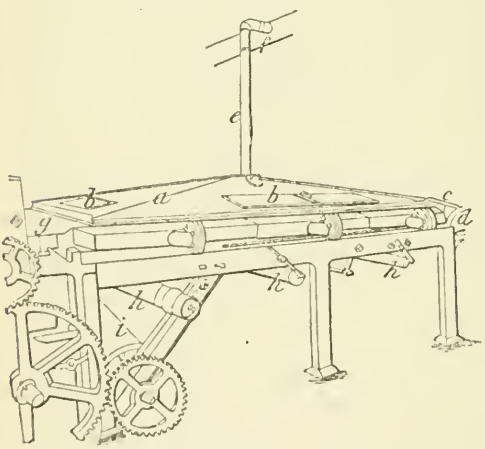
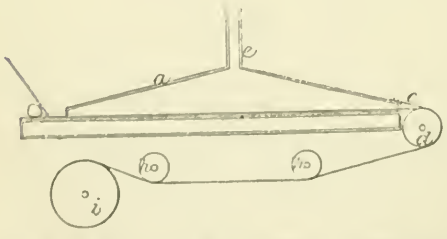


FIG. 3.



At Moseley's works in Manchester, the escape of the naphtha vapour into the atmosphere of the spreading-room is obviated by covering the steam-chest with a shallow box, in such a way that the vapour rising into the space thus enclosed can, by means of a fan, be drawn off by a pipe that enters it at the farther end. The vapour mixed with air, as drawn from all the machines, is driven into a condensing apparatus connected with the freezing machine in use on the premises for other purposes, and there the naphtha is condensed and recovered. The average saving thus effected amounts to over 70 per cent.

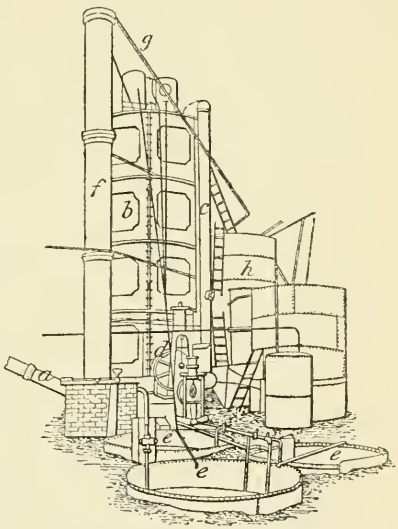
At Quinn's factory at Leyland, near Preston, the vapour diluted with air, similarly drawn off, is absorbed by means of oil. This method is specially applicable to factories in which a freezing machine is not required for other purposes. The naphtha is recoverable by distillation of its solution in the oil. Figs. 2 and 3 represent a spreader in Quinn's works with its cover *a* of thin galvanised iron; plates *b* of glass are introduced to permit the operations to be watched; at the farther end of the spreader a flap *c*, made of canvas, extends from the end of the cover

over the roller *d* beyond, so as to prevent any escape of naphtha in that situation. From the middle of the cover a 3-in. pipe *e* rises, and enters a main *f* with which other similar pipes are connected; *g*, material entering the spreader; *h*, rollers conveying the spread fabric to the drum *i* on which it is gathered.

Fig. 4 represents the plant employed at the same works to effect the condensation of the naphtha, and to recover it for future use. The main pipe *a* from the spreading-room leads to the bottom of a scrubber *b* supplied with creosote oil; *c* is a pipe descending from the top of the scrubber to a Baker's blower *d*. The action of the blower is to draw the mixed air and naphtha vapour from all the spreading-frames through the main pipe and scrubber down the discharge pipe into the open air. In its passage up the scrubber, it meets the oil, and the naphtha is absorbed by it, nothing but air being discharged at the blower. The oil with naphtha in solution runs into a tank or well *e*, from which it is pumped again and again into the scrubber, until it is sufficiently saturated with naphtha. The particular arrangement of the interior of the scrubber adopted here, is that patented by Henry Green of Preston, and used in the gasworks there for scrubbing gas. The recovery of the naphtha from the heavy oil is effected in the same way as a similar separation is effected at shale-oil works. The solution is pumped up to a tower *f* filled with stones, and is made to trickle down, while a jet of steam is thrown in at the bottom. The steam separates the naphtha, and both pass together by the pipe *g* to the worm condenser *h*. The remaining parts of the apparatus figured are devoted to the subsequent separation of the condensed naphtha and water, and the rectification of the naphtha first by mixing it with sulphuric acid and then by distillation. By the use of this apparatus the amount of naphtha recovered on the average is 46 per cent. of the whole used. It would probably be greater if the spreading were performed more slowly.

Drying Spread Fabrics.—After the goods leave the spreading-machines, they are hung up for a few days in a warm room, so as to expel the little naphtha which is retained by the rubber, and which it gives up very slowly.

FIG. 4.



This drying helps to remove the smell of the naphtha, and prevents blistering in curing. The quality of the solvent used, and the temperature of the drying-room, determine how long this "hanging up" must last before curing. As rubber licks up, as it were, the vapours and odours which float about in the drying-room, it would be infinitely better to have a series of drying-rooms, so as not to hang up the more recently spread goods with those which have more or less completely lost their smell of naphtha. Goods which are cured by the cold process are hung up in the same way; but as they have always a

more disagreeable smell, they should have a separate hanging-room to dry in.

Curing Fabrics.—When spread cotton goods have become tolerably firm, or quite dry, they are wound upon hollow sheet-iron cylinders, for curing in open steam, or in a steam-jacketed heater. As the condensed steam spoils these goods, they are carefully wrapped up as air- and water-tight as possible. Since wool and silk are destroyed by the heat necessary to cure rubber in this way, the cold process is the only eligible method of vulcanising. Very frequently, however, cotton goods are treated in the same manner.

In packing the goods for the steam-heater, care must be taken that the fabrics are wound without creases, and are not stretched, as the fibres of the cloth, after curing, will retain their distorted appearance. Double textures are simply wound up; but "surface" goods are first carefully brushed over with very fine French chalk, no excess or loose chalk being allowed to remain. They are then wound up; but, as this necessitates the rubber surface coming into contact with the cotton surface, whereby it is liable to be marked, it is more usual to run 2 pieces together, with the rubber surfaces against each other. This not only prevents marking, but secures an even surface; blisters, from dampness in the cotton, are also prevented.

Double textures are obtained by passing the proofed fabrics through a pair of rollers (the doubling-machine), whilst the surfaces are still sticky or adhesive; these are vulcanised, if required, by means of sulphur incorporated with the compounds, and steam-heat. The doubling-rollers are of solid cast iron, with turned surfaces, 6 ft. long. One is fixed, while the other can be moved by a lever, so as to admit the fabrics to be doubled. As they revolve in opposite directions, they draw the fabric through, and, when tightened up, press the 2 coated surfaces together.

Parkes' process of vulcanising with sulphur chloride is extensively used for surface curing, such as single textures for garments, and sundry small articles manufactured from masticated sheet rubber, as tobacco-pouches, tubing, rings, &c. The chloride is mixed with 30–40 times its bulk of carbon bisulphide for ordinary fabrics; but for solid rubber goods, much more dilute solutions must be used, and a longer immersion allowed, than with stronger solutions, since the surfaces would be overcured, and crack. Sulphur chloride in vapour is preferable in many cases to the mixture in carbon bisulphide. The articles are then suspended in a lead-lined chamber, well varnished with shellac, and heated by steam-pipes; the chloride is gently evaporated, either by placing it in an open dish on the steam-pipes, or by using a small retort, the end of the tubulure of which passes into the chamber. The chloride is evaporated by a small gas-burner. Chlorine, bromine, hypochlorous acid, and several other vapours, can be used in the same way. Although Parkes uses these vapours with solvents of rubber, they act equally well, and in many cases more certainly, without them.

Several improvements for curing double textures have been recently introduced, the most important of which is the Silvertown process. This consists in passing the rubber surface of each piece to be united over a roller, revolving in a mixture of sulphur chloride and carbon bisulphide; the acid mixture does not come into contact with the fabrics, so that no injury can happen either to the colour or the fibres, and the most delicate tissues can be treated. Another process, by Anderson and Abbott, effects the curing by suspending the fabrics or completed garments in a chamber, which is afterwards charged with the vapours of sulphur chloride; it is questionable how far this method can be depended upon, without injury to the fabrics. If the colours are discharged by the sulphur chloride, they are brought back by placing a dish of liquid ammonia in the drying-room.

Single textures are cured by passing

the coated surface over a roller, revolving in the curing-mixture, as above. The fabrics are run on to a large drum, and the cured surface, which is still sticky, is kept from coming into contact with the cloth surface, by making the drum pick up a roller whenever its arms pass the frame which supports them, so that between each 2 layers of material there is a space of about 2 in.; as soon as the bisulphide has nearly all evaporated, the fabrics are run on to a roller for hanging up.

Varnishing Fabrics.—Single textures, when cured, are well wiped over, and varnished with shellac dissolved with liquid ammonia in water. Lampblack is added for black goods; bleached shellac or seedlac is best suited for white or light-coloured goods. The varnishing is performed by passing the fabrics over a roller running in a trough of varnish, or better still, by letting the varnish fall on the rubber surface. It spreads of itself, the excess being removed by passing under a close-fitting scraper or pad. It is dried by running over a large drum or cylinder, heated by steam. Small articles are varnished by a soft sponge.

Joining Fabrics.—Cured or uncured fabrics are joined for garment-making and other articles by cementing together with thin solution. Camphene was largely used a few years ago for softening the edges of rubber for uniting. It leaves the rubber more sticky than any other solvent does. Its present price precludes its use on a large scale. Several coatings are applied, each being allowed to get nearly dry before the next is rubbed on; the 2 adhesive surfaces are then well rolled down by manual labour, and the excess of cement which oozes out is rubbed off, when nearly dry, by a piece of masticated block rubber. Double textures are stripped, so as to cement the rubber surfaces, by applying first a little solvent, which renders the stripping-off easier. In spreading, it is necessary to coat one of the fabrics with less pressure, so as not to drive the rubber into the meshes of the cloth. Such coatings are specially designated "stripping-coats." Without such arrangement, double textures could not be made with water-tight seams.

Rubber Felt.—Rubber felt, felt-paper, or Clark's patent felt, is used for a variety of purposes, such as covering damp walls, protecting silk and other wares from dampness during water-transit, covering telegraph-wire, roofing, &c. Although rubber is now entirely used, guttapercha, alone, or mixed with resins and other matters, has been employed. A pair of ordinary mixing-rolls, running at equal speeds, receive over each a cotton fleece, which is delivered from the carding-machines stationed on opposite sides, so that the 2 fleeces enter together between the rolls, and passing down through an opening in the floor, are led away, or rolled up. A soft dough is carefully laid between the rolls, and as the fleeces pass through, the rubber is squeezed into them. The fabric is vulcanised by incorporating sulphur with the rubber mixtures, and curing in the same way as ordinary spread fabrics. If made with good rubber and naphtha, it should not feel clammy nor soft, but should be dry and tough. Paper can be similarly treated; and, for damp walls, &c., would in many cases be as useful as cotton, while much cheaper. A few years ago, coppered cloth made from this felt was recommended for roofing purposes; it was abandoned principally because the rubber decayed, thus leaving nothing to support the metal. By vulcanising, the rubber could be preserved, but it is not certain that the sulphur, by acting on the copper, might not be a source of fresh trouble. Iodine or bromine incorporated with the rubber would not be liable to this action on the copper. It should form a very useful protection for iron plates on ships, and might be used for a variety of purposes, as it could be cemented on, and, if the cement contained sulphur, or other curative agent, it could be vulcanised by holding a heated body against it.

Colouring Fabrics.—White provides

rubber surfaced fabrics with a permanent brilliant colouring, and slowly cures the rubber or guttapercha, whereby the surface of the fabric remains soft, flexible, coherent, tenacious, and has a peculiar leathery feeling. A filling compound, consisting of a mixture of 20 per cent. sulphur, 50 per cent. zinc oxide, and 30 per cent. suitable colouring material is mixed with the dissolved rubber to cure it and give it body and colour; the surface of the fabrics is coated with this composition. It is essential in preparing this filling that the ingredients be thoroughly dried before mixing, and mixed dry.

Elastic Fabrics.—Burnham has discovered that, by combining the sap of the mangrove (the *cativo* of the United States of Colombia) with rubber in variable proportions, he is enabled to produce permanently elastic waterproof compounds. These compounds are capable of being made into waterproof varnishes by the use of the solvents and additional ingredients ordinarily employed, and are also capable of conversion into products of greater or less hardness by the ordinary process of vulcanisation, either with or without the addition of the whiting, white-lead, or other ingredients. The so-called "cativo" is semi-solid at the ordinary temperature of the atmosphere, but becomes fluid at about 130° F. (54½° C.). In preparing this material to serve as the basis of the compound, it is raised to a temperature slightly above that of boiling water for the purpose of diminishing the strength of its natural odour, and is then strained through a bag-filter to separate it from insoluble impurities. When strained and purified, it exhibits a clear reddish-brown colour. In this condition it is mixed with rubber, either by using appropriate solvents, such as carbon bisulphide or mineral naphtha, or by the employment of hot kneading rolls, by means of which the mixing is effected mechanically. In the latter case the temperature is elevated until the mixture acquires the desired degree of plasticity. The compound may be used as the base for a waterproof varnish, in which case it is preferable to effect the mixing by dissolving the cativo and rubber (say, 3 parts cativo to 1 of rubber) in carbon bisulphide, naphtha, or other solvent, to which may be added linseed oil, tar, or asphalt. When it is desired to produce a vulcanised product, it is better to effect the mixture of the cativo and rubber mechanically by the use of the ordinary kneading rolls. By vulcanising the compound with, say, 5 per cent. of sulphur, a strong elastic product results. For special purposes the proportion of sulphur may be largely increased, so that the product will acquire additional hardness. Metallic oxides, carbonates, or other solid substances may be mixed with the compound for increasing its weight or bulk, or for other purposes. For example, a product suitable for application to canvas may be made by using the following ingredients: 23 parts cativo, 23 of rubber, 36 whiting, 7 white-lead, 5½ litharge, 5½ sulphur. The vulcanisation of the mixture is effected by subjecting it to a temperature of about 275° F. (135° C.).

Cuprammonium and its Allies.—The preparation of these salts and their application to the waterproofing of paper and textiles have been made the subject of much study by Dr. Alder Wright, to whom the following remarks are mainly due. The term "cuprammonium compound" is usually understood by chemists as indicating a member of the class of substances obtainable by the combination of ammonia with certain copper compounds, so as to give rise to a "metallo-ammonium" derivative containing copper. Salts of copper, e. g. copper sulphate, usually combine with 4 proportions of ammonia; thus cupro-tetrammonium sulphate is obtainable in crystals, by simply pouring a concentrated solution of copper sulphate into a solution of ammonia, in such proportions as to obtain a clear deep blue liquid, and then precipitating the crystallised salt by adding a considerable quantity of highly concentrated ammonia

solution, or by shaking with alcohol; in a similar fashion numerous other cuprotetrammonium salts can be obtained. A closely related compound, but possessing somewhat different properties, is cupro-ammonium hydroxide, prepared by dissolving cupric hydrate in ammonia solution, or by agitating together metallic copper and ammonia solution in presence of air, when the copper oxidises and dissolves in the ammoniacal liquor, forming a deep blue liquid, sometimes termed "copperised ammonia."

Most of these compounds are very unstable, breaking up under the influence of heat and water alone, or conjointly; thus cupro-tetrammonium sulphate treated with a large bulk of cold water is partly decomposed, forming a basic insoluble copper sulphate, together with free ammonia and ammonium sulphate; cupro-ammonium hydroxide solution is decomposed by simple addition of alcohol to its ammoniacal solution, a blue substance essentially consisting of hydrated copper oxide being precipitated; the same result ensues on boiling, save that anhydrous black copper oxide is then formed, ammonia being driven off. In presence of a large excess of ammonia, the instability is less marked in all cases; the strongly ammoniacal fluids formed by dissolving copper salts or copper hydroxide in a considerable excess of ammonia water are the "cuprammonium solutions" referred to.

It has long been known that these solutions possess the power of apparently dissolving cellulose and various allied substances; thus paper, cotton-wool, and similar materials, when digested with these fluids, disappear, and are apparently truly dissolved. It is held, however, by some chemists that these are not cases of true solution, but that the substances are simply gelatinised and disseminated through the fluid in a transparent form, as starch is in water. On the other hand, on neutralising the fluid by an acid, or better still, on adding potassium cyanide solution until the blue tint is discharged, the cellulose reappears as a gelatinous precipitate; this result would suggest that the reappearance of the cellulose is brought about by the destruction of the solvent in which it was truly dissolved, viz. the cuprammonium compound, by conversion into ammonia and cupro-cyanide (or into ammonic and cupric salts, if an acid be used). On evaporation to dryness of a cuprammonium solution in which cellulose has been dissolved, a more or less gummy mass is formed, containing the cellulose intermixed with copper oxide, and with ammonia and copper salts if a cuprammonium salt were used, but containing copper oxide and a green copper derivative or compound of cellulose if cuprammonium hydroxide were employed. When the cellulose is in excess, e. g. when the solution is evaporated on the surface of paper or calico, just dipped in the solution, black copper oxide is often not formed at all; but a green varnish-like mass of cellulose conjoined with copper oxide, or of the copper salt of some feeble acid derived from and closely akin to cellulose, coats the surface of each filament of the fabric used, welding and cementing them together. This cement-like "cupro-cellulose," as it may be termed, being insoluble in water, communicates water-resisting properties to the material so treated; moreover, the presence of copper renders the dipped and dried substance less prone than before to the attacks of insects and mould, so that animal and vegetable life of a parasitic nature and fungoid growths are rarely, if ever, to be observed in the substances, even when kept under conditions where boring worms, ants, rot, and mould would be likely to attack them.

To produce the best results in this direction, solution of cuprammonium hydroxide is, for many reasons, preferable to solutions containing cuprammonium salts; not only is the action on cellulose more energetic for a given amount of copper and ammonia in solution, but various other advantages are gained. For example, if ammoniacal solution of cuprammonium sulphate be

used, the dried treated fabrics will contain ammonium sulphate, and sometimes copper sulphate, soluble in water, rendering the material porous if exposed to the action of water in sufficient quantity to dissolve out the soluble matters, and causing more or less tendency to unsightly efflorescence under other conditions. Further, during the drying of materials treated with cuprammonium hydroxide solution, all the ammonia present is volatilised, and may be recovered by appropriate means; whereas, with cuprammonium sulphate solution, a considerable fraction of the ammonia is fixed in the fabric as sulphate, and so lost.

A peculiar property of cuprammonium solutions, and one most important from the manufacturing point of view, is that whereas iron is, as is well known, attacked and dissolved by solutions of ordinary copper salts (e. g. the sulphate, "blue vitriol"), an equivalent quantity of copper being precipitated during the operation, no such action is observable with cuprammonium hydrate solutions; so that cast- and wrought-iron tanks and baths for the reception of the liquor may be used with impunity, as may steel rollers and machinery of all kinds when employed in contact with the liquor, or with fabrics moistened therewith. On the other hand, copper and brass must be studiously avoided in the construction of such appliances, otherwise corrosion and injury are speedily brought about. This peculiarity, as regards the non-action of iron and steel, is the more remarkable in that it is not observed with zinc; this latter metal precipitating copper (and being itself dissolved) with about equal facility, whether the copper be in the form of an ordinary copper salt, or in that of a cuprammonium solution.

For certain purposes, a bath containing a mixture of cuprammonium and the analogous zinc-ammonium hydroxide solutions may be used with advantage; the zinc compound does not of itself sufficiently pectise cellulose to give good results, but when used in conjunction with cuprammonium hydroxide, pectising is brought about by the copper solution, whilst certain advantages are gained by the simultaneous presence of zinco-cellulose and cupro-cellulose in the finished goods. The manufacture of cuprammonium and zinc-ammonium solutions is effected by the simultaneous action of air and ammonia water on metallic copper (or brass, if a mixture of cupro- and zinco-ammonium hydroxides is required), due attention being paid to the recovery of the large amount of ammonia necessarily carried away by the "spent" air during the operation. The manufacture of fabrics, notably paper and canvas, treated with cuprammonium solutions so as to waterproof them and render them rot-proof, and practically free from the attacks of insects and mould, has been recently commenced on the large scale, at Willesden, by the Patent Waterproof Paper and Canvas Co.

The process by which these fabrics are manufactured may be described as essentially consisting of the preparation of a concentrated solution of cuprammonium hydroxide, and the passing of the goods to be treated through a bath of this material at just such a rate as will permit of the pectising and gelatinising of the exterior of the fibres composing the paper or canvas, &c., without wholly disintegrating the mass; so that the material on emerging from the bath retains coherence sufficient to enable it to be passed over and under the usual drums, &c., of a paper mill, and so to be dried in the ordinary way. This drying converts the film of pectised cellulose coating each filament and fibre into an insoluble solid varnish which cements the whole together. In order to build up thick cards, 2 or more reels of paper are employed, passed simultaneously through the bath, and then pressed together and dried as a whole, 2 thicknesses thus treated forming 2-ply card. The best kinds of thick cards are made by passing 2 rolls of 2-ply simulta-

neously through the bath a second time, and pressing them together and drying, thus giving rise to 4-ply card, the thickness mostly adopted for roofing. By repeating this process with 2 batches of 4-ply, 8-ply is obtained; and similarly to any required degree of thickness necessary for special purposes.

A noteworthy point in connection with these processes is that, when certain precautions are taken, the copper present in the ammoniacal fluid imbibed by the material passed through the bath is wholly converted during drying into a compound with the pectised cellulose of an agreeable green tint, and is not deposited as black copper oxide, as it would be on evaporation of the solution without cellulose in a porcelain dish, &c. It is largely the presence of copper in this form that renders Willesden fabrics so free from growths of mould, mildew, rot, and fungoid vegetation generally, and from the attacks of insects. The compound is so stable as to be wholly unaffected by water, when once dry. Of course, mineral acids dissolve out copper to some extent, but this is not the case with ordinary water, apparently not even with London rain.

Instead of cuprammonium hydroxide alone, in certain cases a mixture of cuprammonium and zincammonium hydroxides may be used. The pectised cellulose then contains both zinc and copper, indicating apparently that a zinc cellulose compound has also been formed. Zincammonium hydroxide alone, however, does not pectise paper sufficiently to give good results. In order to pectise paper, &c., thoroughly, when the materials are passed through the baths at a convenient manufacturing speed, it is essential to use a liquid containing 100–150 lb. of ammonia per 100 gal.* (about as much ammonia as is present in solution of ammonia, sp. gr. ·940 to ·960). Such a fluid, when nearly saturated with copper present as pure cuprammonium hydroxide, will contain 20–25 lb. copper (reckoned as metal) per 100 gal. Considerably larger amounts of copper, however, may be taken into solution in the form of cuprammonium salts, or when certain forms of organic matter are also present in the liquor. According to the textbooks, ammoniacal solutions of cuprammonium salts dissolve cellulose, but such fluids are found to be unsuitable for the manufacture of Willesden goods, for a variety of reasons. In the first place, for a given quantity of copper in solution an ammoniacal solution of cuprammonium hydroxide appears to possess a considerably higher pectising power than a similar solution of a cuprammonium salt; next, when a cuprammonium salt, e. g. the sulphate, is used, there is not only a tendency to form a little copper sulphate, which can be washed out of the finished fabric by water (thus rendering the material unsuitable for many purposes, e. g. cattle drinking-troughs, portable sheep-pens, &c.), but further, much ammonium sulphate is formed in the body of the fabric, thus giving rise to a double disadvantage: first, because the ammonia thus fixed is wholly lost, whereas the ammonia in cuprammonium hydroxide is wholly volatilised during the drying, and can be recovered and used over again; secondly, because when the fabric is wetted, the ammonium sulphate is washed out, thus partially opening the texture, and rendering the mass more porous and less impervious to moisture; beside which, the ammonium sulphate sometimes effloresces as an unsightly saline film. For these and other reasons cuprammonium hydroxide, and not a cuprammonium salt, is employed in the manufacture of the so-called "Willesden" goods.

These goods are divisible into 2 classes, viz. (*a*) round or made-up, such as rope, cordage, netting, &c., and (*b*) rolled or flat.

Goods of the first class (*a*) are prepared by simply dipping the made-up materials to be treated into a bath of cuprammonium solution, using certain precautions as to the mode of immersion and its duration, and the strength of the solution. On subsequently drying the dipped fabrics, they are obtained

* 1 lb. per 100 gal. = 1 grm. per litre.

coated and impregnated with cupro-cellulose, which thus not merely forms a kind of varnish-like surface dressing, but further adds strength to the fibres by more or less intimately cementing them together. The freedom from liability to mildew and rot of these products is remarkable, whilst they possess many advantages as compared with similar goods protected by tarring, or dipping in the bark vat, or treatment with other preservative compositions.

Goods of the second class (*b*) constitute a much more important group. These fabrics are essentially of 3 kinds, viz. canvas, scrim, and paper. The former 2 of these classes possess many features in common with the round or made-up goods just described, being prepared in much the same way, saving that the fabric to be treated is usually unwound from one roller and re-wound upon another, after passing successively through the bath and a series of drying rolls somewhat analogous to those of a paper mill. Like Willesden cordage and netting, they exhibit remarkable freedom from moulding and mildewing influences.

Willesden paper manufacture may be subdivided into 2 departments, viz. (1) unwelded, (2) welded (rolled) goods, the first class being a single web or ply of paper of indefinite length passed through the bath, and rolled and dried in much the same way as canvas and scrim; the second class consisting of more than one ply or layer of primary material, incorporated into one solid insoluble sheet or homogeneous panel of indefinite continuous length.

1. Unwelded or "1-ply" paper exhibits much the same general resistance to mildewing and moulding influences as Willesden canvas and cordage. According to the nature of the paper originally treated, different kinds of 1-ply result. Certain coarse varieties furnish a waterproof material excellently adapted for lining packages and wrapping parcels liable to be exposed to damp during transit, and of special value as a first coat of paper to be applied to damp walls. Finer qualities furnish envelopes and stationery possessing the valuable property of not being affected by water. Letters written with such stationery would be as legible as ever (provided the ink were not washed away or bleached) even if the mail-bags containing them were sunk in the ocean or washed overboard, and not recovered until after long periods of immersion. In connection with this may be noticed a mode of fastening envelopes, affording security against opening and tampering with contents, impossible with ordinary gummed envelopes, or with those secured by sealing-wax, either of which, as is well known, can be readily opened by a skilled person, and re-closed without noticeable alteration (an impression of the seal being of course taken in the case of sealed letters, and subsequently used to re-seal them). This method consists in using as fastening material a concentrated cuprammonium solution; the edges of the envelope are moistened therewith, whereby the paper is gelatinised; the envelope is then closed and ironed with a warm flat-iron, when the gelatinised cellulose is converted into an insoluble cupro-cellulose, and the cover is fastened down so securely that the only possible mode of opening is to tear the paper. No amount of steaming or treatment with water will undo the cement, as it would with a gummed envelope. Another application of this same principle consists in the use of a wafer of "Willesdenised" paper, moistened with cuprammonium solution before use. Obviously, the same principle may be applied in the direction of cementing together the edges of sheets of paper so as to form larger sheets, fixing firmly together paper, pasteboard, wood, and analogous surfaces, bookbinding, and in numerous other ways; troughs and dishes, water-tight boxes and packing-case linings are readily prepared thus.

2. Welded Willesden goods have undoubtedly the merit of being the most remarkable and interesting of all, on account of their novelty and important applications; they are all prepared in

substantially the same way, viz. by simultaneously dipping more than 1 ply, and pressing into one compact homogeneous sheet the various layers, whilst still gelatinised or pectised by the action of the cuprammonium solution. According to the nature and thickness of the finished material, various subdivisions of this class may be tabulated, e. g. :—8-ply, panel board; 4-ply, for roofing, building, panelling, decorating; 2-ply, for underlining, interior decoration, floors, damp walls, packing, leaky roofs; 1-ply, described above as unwelded Willesden goods.

Besides these, various kinds of combination fabrics may be noticed, such as those obtainable by simultaneously treating paper and calico, and welding the two together so as to form an article resembling ordinary mounted drawing paper, but differing therefrom in the important character that long-continued immersion and even long boiling in water causes not the least disintegration or separation of the 2 diverse fabrics thus combined; so that military and submarine engineers' and surveyors' plans, and the like, drawn on such paper would be uninjured by being exposed to wet and rain, if the colours or ink were of suitable kinds, so as to resist the action of the water.

Willesden 8-ply is adapted for panel work and use where great strength is required, and is valuable owing to its being made (to special order) 54 or even 60 in. wide, and in continuous lengths; from the nature of this material, there is no fear of its cracking or splitting like ordinary panel board. For boat-building and naval construction generally it is well adapted.

Willesden 4-ply, next to slates and tiles, stands pre-eminent as a durable roofing material, unassailable by weather of all kinds; whilst its strength, combined with lightness and flexibility, render it a most valuable and unique article for practical use and service; more especially are these advantages manifest in connection with up-country and foreign employments.

It would come far cheaper than galvanised iron, in any locality where the cost of transit is heavy, more especially in new districts where the means of communication with the seaboard are but imperfectly opened up. Again, being put up in compact rolls (ordinarily of 2 cwt. each), no space is wasted in packing. Another special advantage is, that being comparatively non-conducting, the heat of a tropical sun is less felt under a roof of this kind than under a metallic one; whilst, on the other hand, the condensation of moisture from warm air inside a hut thus roofed or walled is all but imperceptible, even on a cold night; whereas an iron building, under similar conditions, frequently gives an inconvenient drip of condensed water from the roof, and small streams running down the walls.

For building purposes generally, and interior use, 4-ply offers many advantages. Where the buildings are temporary and intended for subsequent removal elsewhere (e. g. workmen's huts when engaged in railroad construction), the lightness of this material renders it eminently adapted for construction in removable sections; and for more permanent structures it is equally advantageous for numerous reasons. It does not harbour moths or other vermin; in the hottest weather, under a broiling tropical sun, it remains unchanged, and emits no unpleasant odour; it requires no painting, and exempts from the necessity of using pot and brush year after year to prevent corrosion, or to make a neat surface, or render water-tight, being weather-proof in itself. If required for internal decoration, however, it will take paint readily, and, indeed, forms an admirable foundation for the painter and decorator to work upon, in this respect having marked advantages over felt, with which material it has nothing in common, although the two can, if desired, be used in conjunction. In case of fire, although not absolutely indestructible, yet "Willesden" will not readily feed the flames, the copperising and compacting process by which it is made

rendering it far less inflammable than such substances as painted or tarred felt, or wooden shingling; its lightness moreover renders much less massive timbering requisite for the support of roofs, thus again diminishing the risk of damage by conflagration, there being actually less combustible matter about a building erected with this material than is necessary when the weight of a slated or tiled roof has to be supported. A special method of fixing walls and roofs of Willesden paper is recommended (see 'Spons' Mechanics' Own Book,' pp. 618–20). Many such roofs are now standing in perfectly good condition, after upwards of 8 years' exposure to weather of all sorts; similarly, pipes conveying both water and steam have been in use upwards of 3 years below ground at the Willesden works, without any visible deterioration.

Willesden 2-ply is susceptible of being used for many purposes for which 4-ply is applicable, more especially when a less degree of body and substance will suffice. One special purpose to which it is excellently well adapted, is for laying upon or under floor-boards and joists, to avoid damp and draughts. Used as a floor-cloth for stairs and offices, it wears well and is most effective, the cost being only a fraction of that of linoleum, kamptulicon, and similar articles.

Boats made of the paper answer very well in fresh water, but have not been tested in salt water. One advantage in making boats of the paper is that they are lighter than those made of wood, and, in the next place, are very easily repaired. Photographic dishes can easily be made by taking a sheet and pinching up the corner, bulging being prevented by running a thread through the corners. These dishes can be used for chemicals, though it is not advisable to put in a second chemical if the first has remained in the dish for some time. The action of acids upon the card depends upon the concentration as well as the nature of the acid and the temperature. If the card were boiled in a beaker, with weak sulphuric or hydrochloric acid, beyond doubt copper in solution would be found, and, no doubt, there would be less copper in the card than there was before; but, in the cold, very little copper is dissolved out. It is unlikely that the solution of copper in this way would affect the stability of the material for use in galvanic cells. Whether this material can be used for vats for bleaching purposes, is a matter which experience alone can decide, though there is nothing in the character of the material which would unfit it for the purpose. At the same time it is doubtful whether oil of vitriol could be kept in a vessel made of Willesden paper. With regard to ropes being only superficially tinged with the coppery material, that partly arises from the circumstance that the rope is purposely not immersed sufficiently long to enable the fluid to penetrate deeply. As the action of the solution is to dissolve and disintegrate fibres, if thin ropes were saturated all through, they would lose a certain amount of strength. It is not necessary that a rope shall be saturated throughout. As to the paper treated at Willesden, complete penetration of the fluid into each ply of paper is a necessity, in order to obtain a proper product. The principal difficulty in carrying out the process consists in exactly regulating the strength of the solution as regards the amount of copper and ammonia, the nature of the paper and the length of time during which it has to pass through the vat, in order that the solution shall pass into the interior of the paper to the proper extent and no more; for if the action of solution is overdone, the material becomes too soft and tender to be dealt with by the machine. Both the canvas and paper are susceptible of use as a medium for painting, though canvas has not been long in use; but there is every reason to believe that works of art on canvas treated by this process will be less subject to deterioration through injury to the foundation. The paper would have no effect upon any mineral colour employed for decorative purposes. The action of copper

upon certain organic dyes is well known, but these substances are rarely used for painting. The paper can be moulded into any shape. As to the analogy between this paper and paper parchmentised with sulphuric acid, the 2 processes are dissimilar, though chemically the change produced on the paper fibre is of much the same character. There is a certain amount of analogy between the processes; if, for example, a sheet of writing paper is impregnated with cuprammonium to a fair extent, it has much the same texture when finished as parchmentised paper, and microscopically there is the same kind of structure. The quantity of copper left in the paper after treatment will vary very much according to the length of time the paper is allowed to remain in the solution, and the quantity taken up, but in round figures, an analysis of 4-ply paper shows that it contains about 4 per cent. of metal. Among other uses to which the paper may be put, are covering bricks in the brickfield, and making shelters for vineries. Upon the question of whether Willesden paper is a non-conductor for electricity or not, probably if the material were rolled up into a pipe and used for telegraph cables, it would serve very efficiently, though scarcely with any advantage over guttapercha. It certainly does not conduct electricity readily; but as it contains copper, if there happened to be a leaky wire, reduction of metallic copper might be caused, whereby metallic communication would be set up from the wire to the earth, and, therefore, it is doubtful whether the substance could serve for the purpose of insulation. For chemical laboratories, and household matters, there are a considerable number of applications where the material will come in most handily.

Miscellaneous Preparations.—A large number of compounds have been proposed at various times for rendering articles of everyday use more or less impervious to wet. These will now be collected together and arranged under 4 heads, according as they are designed more particularly for felt hats, leather, paper, or textile goods.

Felt Hats.—(1) The stuff of coarse hat bodies is imbued with drying oil, prepared by boiling 50 parts linseed oil with 1 part each of white-lead, litharge, and umber. The felt to be dried in a stove, and then polished by pumice; 5 or 6 coats of oil are required; the surface is at last varnished. When the hat is intended to be stiff, the fabric is to be impregnated, first of all with paste, then stove-dried, cut into the desired shape, and pumiced repeatedly; lastly placed in a hot iron mould, and exposed to strong pressure.

(2) Remove lining of hat, and paint the inside with Canada balsam, made hot. Hats made waterproof and not ventilated will bring on premature baldness; so punch a few small holes in the side.

Leather.—(1) Add to a boiling solution of common yellow soap, in water, solution of alum or alum-cake (alumina sulphate) as long as a separation of white alumina soap takes place; allow the precipitate to subside, wash it with hot water, heat moderately for some time, to expel adhering water, and dissolve the semi-transparent mass in warm oil of turpentine. The solution may be applied by brush, or by dipping and rolling. Oil and colours may be added to the bath, and the substance dried in the air, or more rapidly in a drying room at 90°–100° F. (32°–38° C.), with care to prevent fire.

(2) 100 oz. best white or yellow wax, 6 oz. Burgundy pitch, 8 oz. ground-nut oil, 5 oz. iron sulphate, 2 oz. essence of thyme.

(3) A method of waterproofing leather and raw hides, used in southern Austria, is as follows: impregnate the substance with a gelatine solution, mixed with some mineral salt to coagulate the gelatine in the pores. The following mixtures can be used: (*a*) 1200 water, 15 gelatine, 5 potash bichromate; or (*b*) 1500 water, 50 gelatine, 30 potash bichromate; the temperature of the solution may vary from 53° F. (10° C.), to boiling-point. When

the bichromate percentage is small, the liquor is used cold, and the leather or hide is immersed for 24 hours; as the proportion approaches the point of saturation, the temperature must approximate more nearly to boiling, and the time of immersion be reduced until it becomes momentary. The bichromate solution may be replaced by the following: 1000 water, 10 gelatine, 100 lead acetate, 100 alum; in every case, after impregnation on one or both sides, the leather or hide should be dried, and dressed on both sides with paraffin.

(4) For rendering hose of fire-engines completely water-tight, so as to withstand the greatest pressure, the hose, after being cleaned and dried, is impregnated with a mixture of 100 parts of glycerine and 3 of carbolic acid, which may be done either by drawing the hose through the liquid, or, better still, by brushing it well in. Thus treated, the hose preserves a certain degree of dampness, without, however, being liable to rotting in the least degree, and so suffering deterioration in quality and durability. The brass fittings of the hose are attacked only imperceptibly by the acid contained in the composition; but even this may be easily prevented by giving them before impregnation a coating of weak shellac varnish, or by greasing them well with tallow. The hose must be cleaned every time they have been used, dried, and impregnated anew with the liquid. The previous drying of the hose is, however, not necessarily essential, more especially in winter, when drying is slightly difficult; it suffices to let the water run well out of the hose.

(5) For boots and shoes. Apply to the soles as much copal varnish as they will absorb; and castor oil to the uppers. The castor oil does not prevent subsequent blacking.

(6) 1 oz. beeswax, ½ oz. suet, 2 oz. olive oil, ½ oz. lampblack; melt the wax and suet in the oil, add the lampblack, and stir till cool; warm the shoes and rub in the compound.

(7) Warm the boots by the fire and then rub in paraffin wax; it is, however, apt to soil the stockings by being melted out by the heat of the feet. A saturated solution of paraffin wax in cold naphtha, applied cold, is perhaps better.

(8) Mix together in a pipkin, on the fire, 2 parts tallow to 1 of rosin, and having thoroughly warmed the boots, apply it, melted, with a painters' brush till they will not soak in any more. If the boots are well polished before applying the mixture, they will polish afterwards.

(9) Take about 1 gill of Macintosh's indiarubber waterproofing solution, dissolve it in 2 gills raw linseed oil, adding the oil to the solution gradually. With this liquor paint the boots, giving as many coats, at intervals of 6 or 8 hours, to the leather as it will take in, which may be as many as 10 or 12. The prepared leather takes a brilliant polish.

Paper.—(1) It is a well-known fact that cellulose is soluble in cuprous ammonia solution; paper, linen, and other vegetable tissues laid therein undergo a sort of surface-amalgamation of the fibres, which alters their absorbent powers. A sheet of paper so treated, and dried afterwards, becomes impermeable to water, and this property is not effaced by subsequent boiling. Sheets of paper soaked in the solution and laid one upon the other and rolled, become amalgamated into a kind of cardboard, possessing great elasticity and cohesive power. The cuprous solution may be prepared by agitating copper filings in a closed vessel containing liquid ammonia of 0·88 sp. gr.

(2) Dissolve 8 oz. alum and 3¾ oz. Castile soap in 4 pints water, and 2 oz. gum arabic and 4 oz. glue, separately, in 4 pints water; mix the solutions, heat slightly, dip in the single sheets, and hang up until dry.

(3) Waterproofing pasteboard may be effected with a mixture of 4 parts slaked lime in 3 of skimmed milk, with a little alum added. As soon as mixed, the pasteboard is brushed over with 2 successive coatings of the preparation, and thus becomes impervious to water.

(4) Take pale shellac, 5 oz.; borax,

1 oz.; water, 1 pint. Digest at nearly the boiling-point till dissolved, then strain. This forms also an excellent vehicle for water-colours, inks, &c. If required quite transparent, the lac should be bleached as follows: Dissolve shellac in a lye of pearl-ash, by boiling; filter and pass an excess of chlorine gas through the solution, which will precipitate the white lac. Wash and dry the precipitate, and cast it if desired into sticks.

(5) To make waterproof packing paper, dissolve $1\frac{3}{4}$ lb. white soap in 1 qt. water. In another quart of water dissolve $1\frac{1}{2}$ oz. gum arabic and 5 oz. glue. Mix the 2 solutions, warm them, soak the paper in the liquid, and pass it between rollers, or simply hang up to dry.

(6) Even old newspapers may be converted into waterproof roofing material by applying coats of hot coal tar with a brush, uniting 2 or more thicknesses.

(7) Rendering paper impervious to grease and water. Parchment-paper is plunged into a warm solution of concentrated gelatine, to which has been added $2\frac{1}{2}$–3 per cent. glycerine, and allowed to dry. The resulting paper is impervious to grease. If desired to make a paper water-proof, the same parchment-paper is dipped in carbon bisulphide containing 1 per cent. linseed oil and 4 per cent. indiarubber.

(8) A strong, impervious parchment-paper is obtained by thoroughly washing woollen or cotton fabrics, so as to remove gum, starch, and other foreign bodies, then immersing them in a bath containing a small quantity of paper pulp. The latter is made to penetrate the fabric by being passed between rollers. Thus prepared, it is afterwards dipped into sulphuric acid of suitable concentration, and then repeatedly washed in a bath of aqueous ammonia until every trace of acid has been removed. Finally, it is pressed between rollers to remove the excess of liquid, dried between 2 other rollers which are covered with felt, and lastly calendered. The product is suitable for diaphragms in dialytic operations.

(9) Treat the tissue to be waterproofed with chloride, sulphate, or other soluble salt or salts of zinc or cadmium, in conjunction with ammonia, applied in the form of a solution composed of about 3 parts crystallised zinc sulphate, or 3 parts of a solution of zinc chloride at 96° Tw. (47° B.), and about 2 parts of solution of ammonia of sp. gr. 0·875. The paper which it is proposed to treat is passed through a cistern lined with lead, and specially constructed for this purpose, with an arrangement of rollers, so as to allow the material to pass through at a speed varying from 30 to 36 yd. per minute, according to the thickness. In its passage through the liquor, the material becomes perfectly saturated. From the bath it passes through a pair of squeezing rollers, which remove the superfluous liquor, and harden it by compression. From the rollers it is next passed to a suspending apparatus, then hung along the room in folds in a temperature of 110° F. (43° C.), until it is sufficiently dry to be taken down. The rollers in the cistern, the squeezing rollers, and the suspending apparatus are so speeded that the material is taken from one to the other without any inconvenience or stoppage.

(10) Treat with glue, gelatine, or other similar substances, in conjunction with bichromate or chromate of potash, soda, or alumina, applied in the form of a solution of about 1 part glue or gelatine in about 8 of water at 160° F. (71° C.), and a solution of 1 part potash bichromate in 15 of water. The mode of treatment in this case differs from (9) only in 2 points. (*a*) During the time the material is traversing the bath, as already described, the solution is maintained at 160° F. (71° C.) by means of siphon-pipes charged with steam; (*b*) instead of suspending to dry, the material is immediately passed over 3 steam cylinders 7 ft. in diameter, carrying a pressure of 15–20 lb. to the sq. in. The cylinders are provided with gauges to indicate the pressure they are required to carry, and also with safety-valves to prevent this pressure from

being exceeded. The bath must always be kept in a state of darkness.

(11) The paper is treated with acetate, sulphate, or chloride of alumina, applied in the form of a solution of 1 part of any of these compounds in 6 of water at 160° F. (71° C.). The same conditions are required to produce a waterproof material with these compounds as those described in (9) and (10), with this difference, that it is not absolutely necessary to preserve darkness during the process.

Waterproof paper varnishes.—(12) Pulverise 1 lb. shellac and put it into a bottle with a sufficient quantity of alcohol to cover the resin; cork the bottle tightly, and keep it in a warm place until the resin is dissolved. To 1 qt. of the liquid add 1 oz. ivory black and ½ oz. camphor dissolved in alcohol. Apply with a varnish brush. If too thick to work well, thin with alcohol.

(13) Johnson's green vitriol is dissolved in water, a solution of soap is added to this, and the precipitate of iron soap which is formed is collected. When this precipitate has become dry, and is then dissolved in carbon bisulphide, or in benzole, a fluid is obtained which leaves behind a waterproof layer upon paper or tissue. If the paper or tissue is to remain white, a solution of alum is used instead of that of green vitriol, and a white aluminium soap is then obtained, which is used in the same manner.

(14) Take 4 oz. clean guttapercha, dissolve in 1 lb. rectified rosin oil; add 2 lb. linseed oil varnish, boiling hot.

(15) 1 part dammar resin, 4–6 parts acetone are digested in a closed flask for 2 weeks, and the clear solution is poured off. To this 4 parts collodion are added, and the whole is allowed to clear by standing.

(16) 30 parts white shellac are digested with 500 of ether, and to the solution 15 of lead carbonate are added; it is then shaken for some time and repeatedly filtered.

(17) 5 parts glue are dissolved in 100 of warm water, and this solution is spread on paper. After drying, the paper is soaked for an hour in a 10 per cent. solution of alumina acetate and again dried, in order to give it a final glaze.

(18) 120 parts linseed oil are heated and poured into a mixture of 33 of quicklime and 22 of water, to which 55 of melted rubber have been added, stirring all the time. The varnish is strained and used hot.

(19) 1 part guttapercha is carefully digested in 40 of benzene on the water bath, and the paper is covered with it. This varnish can be drawn or written on, and it does not render the paper transparent or spotted.

Textiles.—Without considering the methods by which cloth is waterproofed with rubber, there are several processes in practical use by which cloth is rendered non-absorbent of water—and for all practical purposes waterproof—without materially affecting its colour or appearance, greatly increasing its weight, or rendering it entirely air-proof. These depend mainly upon the reaction between 2 or more substances, in consequence of which a substance insoluble in water is deposited in the fibres of the cloth.

(1) Lowry's process. 2 oz. soap, 4 oz. glue, 1 gal. water. Soften the glue in cold water, and dissolve it together with the soap in the water by aid of heat and agitation. The cloth is filled with this solution by boiling it in the liquid for several hours, the time required depending upon the kind of fibre and thickness of the cloth. When properly saturated, the excess of liquid is wrung out, the cloth is exposed to the air until nearly dry, then digested for 5–12 hours in the following solution: 13 oz. alum, 15 oz. salt, 1 gal. water. It is finally wrung out, rinsed in clean water, and dried at a temperature of about 80° F. (27° C.).

(2) Paut's process requires a small quantity of oil, but in other respects resembles the last. It is given as follows: 1 lb. sodium carbonate, ½ lb. caustic lime, 2¼ pints water. Boil together, let it stand to settle, then draw off the clear lye, and add to it

1 lb. tallow, ½ lb. rosin, previously melted together. Boil and stir occasionally for ½ hour, then introduce 3 oz. glue (previously softened), 3 oz. linseed oil, and continue the boiling and stirring for another ½ hour. In waterproofing, ½ oz. of this soap is mixed with 1 gal. hot water, and in this the goods are soaked for about 24 hours, according to thickness and character. The pieces are allowed to drain until partly dried, then soaked for 6 hours or more in a solution prepared as follows: 1 lb. aluminium sulphate, ½ lb. lead acetate, 8 gal. water. Shake together, allow to settle, and draw off the clear liquid. Wring out after rinsing, and dry at a temperature of 80° F. (27° C.).

(3) Bienvaux uses, instead of glue and oil as above, the gelatinous portion of sea-wrack grass, with a small quantity of a drying oil and common rosin-soda soap.

(4) In Reimann's process, the cloth is passed slowly by machinery through a tank divided into 3 compartments, the first containing a warm solution of alum, the second a warm solution of lead acetate, and the third pure water, which is constantly renewed. The cloth on passing from the latter is brushed and beaten to remove the salt adhering to the surface, and finally hot-pressed and brushed. In this case, lead sulphate is deposited in the fibres.

(5) In Townsend's process, 2 solutions are used as follows: 20 lb. dextrine, 10 lb. white soap, 16 gal. water. The solution is boiled for some minutes, and if colour is required, 1 pint logwood liquor is added. The second solution consists of a saturated solution of alum in water, or 6 lb. zinc sulphate, 9 gal. water.

(6) Bullard's process is somewhat similar to Reimann's. In this, strong aqueous solutions of aluminium sulphate and lead acetate are used alternately.

(7) Berlin waterproof cloth is said to be prepared by saturating the cloth in a solution of aluminium and copper acetate, then dipping it successively in water-glass and rosin-soap.

(8) A bath heated to 194° F. (90° C.) is made of 13¼ lb. liquid Bordeaux turpentine, 3¼ lb. tallow, 1 lb. wax, and ½ lb. storax; the articles are immersed for a few minutes, then passed between heated rollers to remove excess.

(9) For some time past the Belgian War Department has conducted a series of experiments at Valvorde, on the waterproofing of soldiers' uniforms by means of liquid alumina. With respect to the hygienic side of the question, the medical authorities have satisfied themselves that the articles of dress thus treated permit the perspiration to pass off freely, and chemical analysis has proved that the preparation used in no way injures the materials, or destroys their colour. More than 10,000 yd. of materials, re-dressed 2 or 3 times over, notwithstanding the rinsing and washing to which they have been subjected after having been soiled, and after constant wear, remained perfectly waterproof. The only drawback to the process appears to be that it is not very economical, and, to ensure the desired result, must be conducted on a large scale, which requires a considerable amount of plant. The following is the process employed:—Alumina acetate is obtained by making solutions of equal parts of alum and lead acetate in separate vessels, and then mixing them together. Lead sulphate will be thrown down, leaving alumina acetate in solution, which must be decanted. The materials to be waterproofed are soaked in this solution, and then withdrawn without being wrung, and dried in the air.

(10) Bellefroid produces an impermeable coating, which consists firstly of a solution of stearine pitch, one of the by-products of candle-making, which pitch, in order to be used in the fabrication of the compound, is previously completely oxidised by exposure to the air. In order to complete this oxidisation, the pitch is spread out in very thin layers, and exposed to the outer atmosphere for a period of at least 2 years. This exposure is absolutely necessary, judging from experiments repeatedly made. The solution is after-

wards effected in the following manner. A mixture consisting of 75 lb. stearine pitch, 150 lb. water, and 5 lb. caustic soda at about 35° to 36°, is put into a boiler or vessel of any suitable shape, having a second or double bottom so as to allow of the removal of impurities which will settle at the bottom of the vessel. The mixture is boiled for 12 hours over a strong fire, after which 52 pints water are added, and the boiling is continued for another 12 hours. The solution thus obtained is then poured out in an open vessel, and left exposed to the open air for 8 days, for the purpose of being clarified, and enabling the impurities to settle at the bottom.

(11) Piron has invented a process for tanning textile fabrics, which renders them waterproof, and at the same time, it is said, proof against decay, while their suppleness is not diminished, and their weight not appreciably increased. Arguing from the high state of preservation in which the bands which surround the heads of Egyptian mummies are found to this day, and which are impregnated with a kind of resin, Piron had recourse to the substance extracted from birch bark, and which is now used to perfume Russia leather. When the fine white bark of the birch tree is distilled, it yields a light oil, nearly ¼ of which consists of the special phenol, or carbolic acid, which gives the well-known odour to Russia leather. It is now found that the residue, or green tar of the birch, which is obtained from Kostroma, yields neither acid nor alkaloid, and it forms, with alcohol, a solution of great fluidity, which, however, when once dried, is unacted upon by alcohol. It is this substance, which will unite with the most brilliant colours, that is used by Piron for treating textile fabrics. Not only does it fill the capillary vessels, but it also coats them with a varnish of great elasticity, which is unattackable by acids and sea water, while it also stands great changes of temperature. The aromatic odour of articles thus treated drives away insects; there is no space for microscopic vegetation, and neither air nor water can penetrate into the tissues. This process is applicable to all vegetable products, such as sailcloth, cordage, blinds, and awnings.

(12) Sackcloth or canvas can be made as impervious to moisture as leather, by steeping it in a decoction of 1 lb. oak bark with 14 lb. boiling water. This quantity is sufficient for 8 yd. of stuff. The cloth has to soak for 24 hours, when it is taken out, passed through running water, and hung up to dry. The flax and hemp fibres, in absorbing the tannin, are at the same time better fitted to resist wear.

(13) Waterproof Coat. — Isinglass, alum, soap, equal parts; water sufficient. Dissolve each separately, and mix the solution, with which imbue the cloth on the wrong side. Dry, and brush the cloth well, first with a dry brush, and afterwards (lightly) with a brush dipped in water.

(14) For awning or apron.—Dissolve 1 oz. yellow soap in 1½ pint water by boiling; then stir in 1 qt. boiled oil, and when cold add ¼ pint gold size.

(15) Seamen's Oilskins.—The material should be fine twilled calico, dipped in bullocks' blood and well dried in a current of air, then 2 or 3 coats of raw linseed oil with a little gold size or litharge in it (say 1 oz. to 1 pint of oil). Each coat should be allowed to dry thoroughly before the next is put on (as before in a current of air, care being taken to shelter it from both sun and rain). Oilskins made in this way, both here and in the tropics, have stood for years.

(16) Waterproofing linen or calico —the manner in which sea-fishermen do coats and leggings.—Whatever the article is, let it be stretched on a table. Make very thick paint of whatever colour is wished. An invisible green is, perhaps, as good as any. Take a large lump of common brown soap, pretty freshly cut from a bar, in the left hand, and every time you replenish the brush with paint rub well on the soap, and take up as much as possible, and rub well on one surface of the calico or linen. It will take long to do,

and should be hung in the windiest place you can find. Summer is the best time, but a month will see it in very usable order, and you will have as supple and perfectly waterproof a garment as paint can make. After wearing a few times, a second coat would be advisable, which will dry in half the time of the first, and must be done in the same way.

(17) For canvas.—A solution containing equal parts by weight of gelatine and chrome-alum. It is not advisable to mix more of the solution at once than is sufficient to give the canvas one coat, as, if the mixture once sets, it cannot be reliquefied like a plain solution of gelatine, and hence, if the quantity of canvas to be waterproofed is but small, it would, perhaps, be preferable to coat with plain gelatine solution until quite impervious to cold water, and then to thoroughly soak, say for 24 hours, in a strong solution of chrome-alum.

(18) For sail-cloth.—Grind 96 lb. English ochre with boiled oil, and add to it 16 lb. black paint. Dissolve 1 lb. yellow soap in 1 pail of water on the fire, and mix it while hot with the paint. Lay this composition, without wetting it, upon the canvas, as stiff as can conveniently be done with the brush, so as to form a smooth surface; the next day, or the day after (if the latter, so much the better), lay on a second coat of ochre and black, with a very little, if any, soap; allow this coat a day to dry, and then finish the canvas with black paint.

(19) For woollens.—Boil $4\frac{1}{2}$ oz. white soap in $2\frac{1}{2}$ gal. water, and separately dissolve $5\frac{3}{4}$ oz. alum in $2\frac{1}{2}$ gal. water. Heat the 2 solutions to 190° F. (88° C.), pass the fabric first through the soap bath and then through the alum, and finally dry in the open air.

(20) Oil-cloth.—The manner of making oil-cloth, or "oil-skin," was at one period a mystery. The process is now well understood, and is equally simple and useful. Dissolve some good resin or lac over the fire in drying linseed oil, till the resin is dissolved, and the oil brought to the thickness of a balsam. If this be spread upon canvas, or any other linen cloth, so as fully to drench and entirely to glaze it over, the cloth, if then suffered to dry thoroughly, will be quite impenetrable to wet of every description. This varnish may either be worked by itself or with some colour added to it: as verdigris for a green; umber for a hair colour; white-lead and lampblack for a grey; indigo and white for a light blue, &c. To give the colour, you have only to grind it with the last coat of varnish you lay on. You must be as careful as possible to lay on the varnish equally in all parts.

(21) A better method, however, of preparing oil-cloth is first to cover the cloth or canvas with a liquid paste, made with drying oil in the following manner: Take Spanish white or pipe-clay which has been completely cleaned by washing and sifting it from all impurities, and mix it up with boiled oil, to which a drying quality has been given by adding a dose of litharge, $\frac{1}{4}$ the weight of the oil. This mixture, being brought to the consistence of thin paste, is spread over the cloth or canvas by means of an iron spatula, equal in length to the breadth of the cloth. When the first coating is dry, a second is applied. The unevennesses occasioned by the coarseness of the cloth or the unequal application of the paste are smoothed down with pumice, reduced to powder, and rubbed over the cloth with a bit of soft serge or cork dipped in water. When the last coating is dry, the cloth must be well washed in water to clean it; and, after it is dried, a varnish composed of lac dissolved in linseed oil boiled with turpentine is applied to it, and the process is complete. The colour of the varnished cloth thus produced is yellow; but different tints can be given to it in the manner already pointed out. An improved description of this article, intended for printed and figured varnished cloths, is obtained by using a finer paste and cloth of a more delicate texture.

(22) Varnished silk.—This material, often employed for umbrellas, is prepared much in the same manner as (21), but with a paste composed of linseed oil

boiled with ¼ litharge, 16 parts dried and sifted pipe-clay, 3 of litharge very finely ground, dried, and sifted, and 1 of lampblack. After washing the silk, fat copal varnish is applied instead of that used for oil-cloth.

(23) For linen.—A solution of alumina sulphate in 10 times its weight of water, and a soap bath of the following composition: 1 oz. light coloured rosin and 1 oz. crystallised soda are boiled in 10 oz. water until dissolved. The rosin soap is precipitated with ½ oz. table salt, and is subsequently dissolved along with 1 oz. white curd soap in 30 oz. hot water. It should be put in wooden tubs for use. On made up articles, the two solutions can be applied with a brush and then rinsed off.

(24) Parone, of Turin, proposes the following method of rendering textures waterproof. In 14 pints of water, heated to about 180° F. (82° C.) dissolve 10½ lb. gelatine and 21 lb. castor-oil soap; then add 10½ lb. lac, shaking the liquid till the lac is completely dissolved. Take it off the fire, and add to the mixture in small quantities at a time 21 lb. powdered alum, shaking it till the alum is dissolved. The liquid thickens, forming an insoluble alumina soap which remains closely incorporated with the gelatine and lac. It is spread over the textures with a brush.

(25) Cooley gives the following recipe for waterproofing, which appears to have the advantage of having been tried with success:—"A simple method of rendering cloth waterproof, without being airproof, is to spread it on any smooth surface and to rub the wrong side with a lump of beeswax (perfectly pure and free from grease), until it presents a slight, but even, white or greyish appearance; a hot iron is then passed over it, and, the cloth being brushed whilst warm, the process is complete. When this operation has been skilfully performed, a candle may be blown out through the cloth, if coarse, and yet a piece of the same placed across an inverted hat may have several glassfuls of water poured into the hollow formed by it, without any of the liquid passing through. Pressure or friction will alone make it do so."

(26) For canvas.—The following is highly recommended as a cheap and simple process for coating canvas for wagon tops, tents, awnings, &c. It renders it impermeable to moisture, without making it stiff and likely to break. Soft soap is dissolved in hot water, and a solution of iron sulphate added. The sulphuric acid combines with the potash of the soap, and the iron oxide is precipitated with the fatty acid as insoluble iron soap. This is washed and dried, and mixed with linseed oil. The soap prevents the oil from getting hard and cracking, and at the same time water has no effect on it.

(27) Waterproofing oil.—Take 20 oz. lard oil, 10 oz. paraffin, 1 oz. beeswax; heat the oil over a slow fire, and when hot add the paraffin and wax; allow the whole to remain over the fire until the latter articles are melted, and add a few drops of sassafras oil or other essential oil to preserve it.

(28) Sailcloth impervious to water, yet pliant and durable.—Grind 6 lb. English ochre with boiled oil, and add 1 lb. black paint, which mixture forms an indifferent black; 1 oz. yellow soap dissolved by heat in ½ pint water, is mixed while hot with the paint. This composition is laid upon dry canvas as stiff as can conveniently be done with the brush. Two days after, a second coat of ochre and black paint (without any soap) is laid on, and, allowing this coat time to dry, the canvas is finished with a coat of any desired colour. After 3 days it does not stick together when folded up. This is the formula used in the British navy yards, and it has given excellent results. A portable boat may be made of canvas prepared in this way, and stretched on a skeleton frame.

(29) For woollen cloth.—4 oz. powdered alum, 4½ oz. sugar of lead, dissolved in 3 gal. water, and stirred twice a day for 2 days. When perfect subsidence has taken place, pour off the clear liquid only, and add to it 2 dr. isinglass, previously dissolved in warm

water, taking care to mix thoroughly. Steep the garments in this mixture for 6 hours, after which hang up to drain and dry. Wringing must be avoided. This recipe is used by woollen-cloth waterproofers.

(30) Dujardin's process for all kinds of textiles is as follows. Place in a mortar 12 oz. alumina and potash sulphate reduced to powder, and 12 oz. lead acetate; bray till the mixture is quite deliquescent. Add 7 oz. pulverised potash bicarbonate, and 7 oz. soda sulphate; bray till completely combined. Pour in $4\frac{1}{4}$ oz. calcined magnesia, and continue braying while adding $8\frac{3}{4}$ pints water. Pour the whole into a bucket containing 11 gal. river or rain water, which must be fresh. Shake the whole until there is complete solution, which takes place in 20 minutes. Pour the liquid thus obtained into a convenient receptacle holding about 22 gal., in which have been dissolved $5\frac{1}{4}$ lb. oleine soap in 11 gal. rain or river water. Boil for about 20 minutes. To render a texture waterproof, it is then sufficient to put in this liquid either by hand or machinery, until it is perfectly impregnated in all its parts. Care must be taken during the whole operation to stir the mixture well, that no deposit may be formed. The texture is then withdrawn, left to drip, and dried. It is afterwards washed in plenty of water, dried, and dressed as usual. In this condition the texture is waterproof, but penetrable by air, which is indispensable for health. This process does not alter tints at all, but if the materials have very delicate tints, it is necessary to take account of the composition of these colours, and compose the bath accordingly. The potash bicarbonate and soda sulphate must then be sometimes replaced by the same quantity of salts of iron, copper, zinc, lead, or some other metallic salt suitable for preserving colours. To prepare linen, leather, or wood, add $3\frac{1}{2}$ oz. margarine to the bath. When it is desired to prepare cotton or paper, it is well to add to the bath $1\frac{3}{4}$ oz. gelatine, and $3\frac{1}{2}$ oz. light-coloured rosin. After that, dry in the open air or at the fire, and the products will be perfectly impermeable, and resist every kind of washing. Paper paste may be even soaked in the vat, and thus an impermeable paper obtained, the above process replacing the sizing.

PACKING AND STORING.—There are many articles of delicate odour or colour, or of a deliquescent character, or liable to ignition, or apt to suffer from insects or damp, or easily broken, which demand great care in their package and storage. Some practical hints on this subject will, therefore, not fail to be of interest.

Glass and China.—The safety of glass articles packed together in a box does not depend so much upon the quantity of packing material used, as upon the fact that no two pieces of glass come into actual contact. In packing plates, a single straw placed between two of them will prevent them from breaking each other. In packing bottles in a case, such as the collecting case of the microscopist, and the test case of the chemist, rubber rings, slipped over each, will be found the best and handiest packing material. They have this great advantage, that they do not give rise to dust.

One of the most important things is to season glass and china to sudden change of temperature, so that they will remain sound after exposure to sudden heat and cold. This is best done by placing the articles in cold water, which must gradually be brought to boiling, and allowed to cool very slowly, taking several hours. The commoner the materials, the more care is required. The best glass and china are well seasoned before sold. Such wares may be washed in boiling water without fear of fracture, except in frosty weather, when, even with the best, care must be taken not to place them suddenly in too hot water. China that has any gilding may on no account be rubbed with a cloth of any kind, but merely rinsed first in hot and afterwards in cold water, and then left to drain till dry. If the gilding is very dull and requires polishing, it may now and then be

rubbed with a soft wash-leather and a little dry whiting; but this must not be more than once a year, or the gold will be rubbed off and the china spoilt. When put away in the china closet, pieces of paper should be placed between them to prevent scratches on the glaze or painting, as the bottom of all ware has little particles of sand adhering to it, picked up from the oven wherein it was glazed. The china closet should be in a dry situation, as a damp closet will soon tarnish the gilding of the best crockery. In a common dinner service, it is a great evil to make the plates too hot, as it invariably cracks the glaze on the surface, if not the plate itself. We all know the result—it comes apart. The fact is, when the glaze is injured, every time the "things" are washed the water gets to the interior, swells the porous clay, and makes the whole fabric rotten. In this condition they will also absorb grease, and, when exposed to further heat, the grease makes the dishes brown and discoloured. If an old, ill-used dish be made very hot indeed, a teaspoonful of fat will be seen to exude from the minute fissures upon its surface. These latter remarks apply more particularly to common wares. As a rule, warm water and a soft cloth are all that is required to keep glass in good condition; but water-bottles and wine decanters, in order to keep them bright, must be rinsed out with a little muriatic acid, which is the best substance for removing the "fur" which collects in them. This acid is far better than ashes, sand, or shot; for the ashes and sand scratch the glass, and if any shot is left in by accident the lead is poisonous. Richly cut glass must be cleaned and polished with a soft brush, upon which a very little fine chalk or whiting is put; by this means, the lustre and brilliancy are preserved. (*Boston Journal of Chem.*)

Deliquescent Salts.—(1) Lime chloride and other deliquescent salts may be packed in shaving paper, in cardboard boxes, pasted up and then well soaked in melted wax, paraffin, &c.

(2) The difficulty experienced in preserving caustic soda in a powdered state, owing to the tendency of its particles when exposed to the atmosphere, to deliquesce and combine and mass together, is said to be overcome by mixing with the soda a quantity of powdered sand sufficient to protect the particles of soda from such contact with each other as will cause them to mass together, and also sufficient to shield, in a measure, the particles of caustic from contact with the atmosphere. Caustic soda thus treated is applicable generally in the arts, and can be handled with greater facility than the ordinary commercial article. Where it is to be used as a flux in the manufacture of cast iron, 1 part ground sand may be used to 5 of ground caustic soda; but the quantity of sand may be materially increased, though a less amount will not prove effective. While the sand operates in a measure to protect the soda from atmospheric influences, and prevent contact of its particles, there is no chemical combination between the sand and soda which would cause it to solidify and harden, as would be the case were powdered limestone, for instance, used. In practice the soda and sand are ground up to a powder, either separately or together, and immediately mixed. From the facility with which the article prepared can be handled, it is especially adapted for use as a flux in the manufacture of cast iron, though for the same reason it also commends itself to the trade generally.

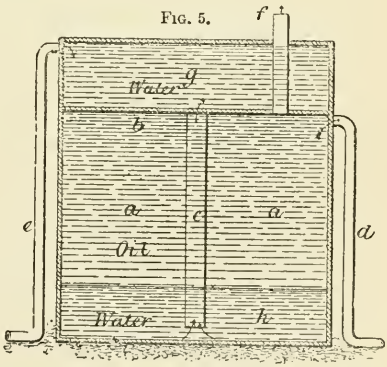
Phosphorus.—Phosphorus should be kept in a place where no damage can result in case the water, in which it is packed, should leak out, and the air obtain free access to it. This is the general rule; its practical application may vary with the circumstances. The governments on the continent of Europe usually prescribe that it must be kept in the cellar, in a locked closet. It is often kept in strong vials, filled with water, which are stoppered with a good cork; and the vial is placed inside of a tin box provided with a well-fitting lid. Phosphorus is usually put up and sold in tightly-soldered tin

cans filled with water. These cans often begin to rust on the outside, and it will happen, occasionally, that the rusting process will penetrate through the tin, causing the water to leak out, and producing a more or less slow, though sometimes quite rapid combustion of the phosphorus. This has sometimes happened when no person was present in the warehouse or store-room, and has been the cause of several fires. The accident may be prevented by carefully *painting* the tin cans, as soon as received, with several layers of white paint, so as not to leave the least portion of tin exposed. Should a large stock have to be carried, it is advisable to paint the cans freshly at least once a year.

Fulminates.—These exceedingly dangerous compounds, liable to explode either by friction or concussion, are rendered safe by keeping them thoroughly immersed in water.

Explosive Fluids.—Petroleum is an example of several fluids, heavier than water, which are liable to ignition, or explosion, or both, when their vapour comes into contact with flame or a body at a high temperature. All such fluids (for instance, carbon bisulphide) may be rendered quite innocuous by storing them under a layer of water. A convenient tank for the purpose is shown in Fig. 5: *a*, space for mineral oil or other fluid to be stored; *b*, diaphragm; *c*, balance-pipe; *d*, filling and emptying pipe for fluid; *e*, inlet and overflow water-pipe; *f*, vent-pipe; *g*, water layer above the fluid; *h*, water layer beneath the fluid. The tank is first filled with water by the pipe *d*, entering immediately under the diaphragm; the admission of water is continued until it has passed up the balance-pipe *c*, and filled the space *g*, driving out the air by the vent *f*. The petroleum or other fluid is then forced through *d*, displacing the water, which passes up *c*, into *g*, the surplus escaping by the outlet *e*. When the vent *f* is closed, no air can mingle with the contents, and no evaporation can take place. In order to draw fluid out, water is forced in by *e*.

FIG. 5.



With regard to the material for the construction of petroleum receptacles, Dr. Stevenson Macadam states that lead will spoil lamp oil in a week or less; iron does not detract from the illuminating qualities, but deepens the colour and causes a rusty deposit; zinc, solder, and galvanised iron are all deleterious. Metals which do not seriously damage the oil, but which still cause its deterioration by contact prolonged for months, are tin, copper, and tinned copper, common solder containing lead being excluded from use in their manufacture. Stoneware, slate, and enamelled iron are therefore recommended.

It has been asserted that the addition of a little powdered soapwort (*Saponaria officinalis*), digested in water, to petroleum, causes it to form a solid mucilage, and that the subsequent application of a little phenol (carbolic acid) causes it to resume perfect limpidity.

Flowers.—Always cut the flowers early, in the cool of the morning, and when in their prime. Take a piece of cotton-wool, wet it, and wring it out, then twist it about the stalk. If tin boxes are used, they must not have sharp corners, or they will be rejected at the post-office, but, when properly made, they excel all others for the

purpose in question. At the bottom of one of these, place a piece of stout brown paper (if thin, double it); let this be well damped, then lay the flowers carefully in, placing a piece of "silver" or tissue-paper between them, to prevent their bruising each other. Over all place a piece of the same paper, and on this a little cotton-wool. Cover the box with paper. Modes of faulty packing may be mentioned as a warning against their adoption:—(1) Placing the flowers in contact with dry cotton-wool, which clings to them, and abstracts their moisture; (2) putting them in tin boxes, such as have contained lucifers, &c., which invariably get crushed in passing through the post-office; (3) putting the cotton-wool about them too wet, the moisture from which gets shaken over the flowers, and spoils their colours; (4) cutting the flowers after exposure to the sun, which ensures their falling to pieces on their journey; this also occurs if the blooms are stale. Some persons sending seedling flowers for an opinion, think it best to cut them when not fully open, knowing that they will expand in water; but they should learn they do not show their true character, either in shape or colour, under such circumstances. A better plan is to cut off the pistil directly it can be done: this will ensure the flower lasting a considerable time.

Articles of Delicate Odour.—Hitherto the question of packing delicate goods has been viewed almost entirely from what may be called the strength-of-materials standpoint. Manufacturers and importers have found that ordinary packing material of a certain thickness and weight was sufficiently strong to withstand the blows received in transit, and have forthwith adopted this as the only condition necessary to be fulfilled in their packages, unless, indeed, anything cheaper should come into the market, in which case most probably it would be used instead. There is one exception to this which has recently occurred. During the last few years there has been a decided increase in the demand for tastily and attractively packed goods—goods of all kinds, in fact, put into such packages that the eye of the purchaser should be attracted by the appearance. The natural result of this has been the employment of any and every material which was adapted to increase the ornamentation, regardless of whether it was adapted for preserving the contents from injury. Packages in which wood is used have given the worst illustration of this erroneous style of packing, green wood being frequently employed, partly, perhaps, because of its working more readily, and woods which either have or develop an unpleasant odour being used because of their pretty markings or suitable colour, while it has not been uncommon of late to employ some kinds of wood which are to a certain extent absorbent, and retain any smell with which they come in contact.

Where goods of an oily or greasy character have to be packed, and the escape of the oil may to a considerable extent be attended with the risk of fermentation or rancidity, grease-proof paper, or some such packing has to be used, and up to the present this paper is unsatisfactory in character indeed, unless very costly kinds are used. In considering the question of export goods, we have, at the outset, to face the fact that goods stowed on board ship have necessarily to be packed in the hold, and to remain there for some time—it may be for weeks or even months—and that wherever the voyage may be to it is almost certain that the temperature to which they are subjected in the hold during nearly the whole time is far in excess of our ordinary English atmospheric temperature. To this must be added another fact which has a great bearing on the question, and that is that the atmosphere of the hold of a vessel is saturated with moisture, and very frequently *supersaturated*. Bilge water exists in small quantities in every vessel. Almost every cargo contains goods in such a state of moisture that they are capable of giving off moisture when the temperature is raised, and there can be few cir-

cumstances under which the air of a ship's hold, when the latter is stowed with cargo, will contain less than the full saturation amount of moisture. But the temperature of the hold must vary from time to time, very slightly, it is true, but probably a small diurnal variation of some 1° or 2° would generally appear. As soon as the diurnal, or perhaps more probably nocturnal, fall of temperature takes place, moisture in the form of dew or cloud would be produced and deposited upon the goods. This is not theory only, but a fact which has been noted in numbers of cases, for the moisture so deposited is always first found upon the top or upper surface of the packages. There is a great deal of importance in this saturation or supersaturation with moisture. Dry air has very little effect upon most natural products beyond a certain amount of desiccation, and its action upon metallic substances is very slight. Most air, on the contrary, acts rapidly and energetically upon metallic bodies, and is the most active agent in setting up decomposition in organic bodies. This is not merely a surface effect, but depends upon the specific capacity which almost all organic substances appear to have for water. Leather, wood, tea, bark, straw, each absorb a certain definite amount of moisture corresponding to the variety of the article itself—not merely its species but its variety—and the moisture of the air in which it is placed. Thus, in the case of, say, 4 samples of tea, of four different kinds, if exposed to air saturated with moisture they will absorb more moisture than they previously contained, but when again exposed to air in what may be called its normal condition in this country—that is, not saturated—the excess of moisture absorbed would be given off again, and while this excess is escaping into the atmosphere it may carry with it some of the aroma belonging to the goods themselves. Nearly everybody would admit that the alternately heating and cooling of any article with a delicate smell would injure that smell either in quantity or quality, or both, but it is equally true that alternately moistening and drying such an article—in other words producing such an effect as would be obtained by an exposure alternately to a supersaturated atmosphere and to an atmosphere not saturated with moisture—would have a like effect.

Dealing still further with the exterior of the package, this deposition of moisture in the form of dew on the exterior has another important effect. This water is precipitated in the air in the form of minute, almost infinitesimally small, water globules, and these have a strong solvent action on any gases or vapours which are present in the air, and which are thus in a more active condition when brought in contact with the goods on which the dew falls. Suppose the air in the hold of a ship to be impregnated, as it always is, with carbonic acid, and also slightly saturated with acetic acid generated from some source or other—the dew deposited on any change of temperature will become saturated with both carbonic and acetic acids, and will obviously be a dilute acid in the most suitable form for acting upon any metallic surfaces with which it comes in contact. Not only so, but leather or cloth goods may be rotted by such an action during a long voyage, and the causes may erroneously be put down to sea damage.

It is notorious that a large proportion of tinned goods which come to this country are injured so as to be rendered unsaleable, but it is not equally well known that a large number of those which are actually sold are really in a condition which renders them unfit for food. It very frequently happens that when tinned fruit or fish or meat goes bad the tin becomes what is technically known as "blown." This "blown" condition is the expansion or bellying outwards of the ends and sides of the tin, and is produced by the liberation of gas within the tin itself, which should have been almost in a vacuous state. In some cases the gas which causes the

"blown" state is produced by the decomposition of the tinned substance, and many tins are absolutely burst by the force with which this gas escapes. But in other cases a small amount of free acid, or an acid still present in the substance itself or generated by its decomposition, acts upon the iron when it is imperfectly coated with tin, or upon the lead if the proportion of lead in the tin is too high, and the gases are liberated which at once set up an objectionable state in the contents of the tin, and bring about its destruction, either by bursting the tin by the internal pressure of the gas, or perforating it by the action of the acid upon the uncovered points, which are necessarily those most easily affected by the acids. Accompanied by this comes another and perhaps equally serious result. The tin, some of the iron, and the lead contained in the tin are dissolved, and the contents of the can become contaminated with these metallic substances. In some cases this contamination is very serious. It is uncommon, for instance, to meet with a sample of tinned salmon or lobster which is in a really good condition, viewed from a chemical standpoint, and acid fruits such as peaches, apricots, and plums, seldom remain good for the second season. To obviate this result various methods have been proposed. In many cases the interior of the tin has been lacquered or coated with some supposed impervious varnish, but this more frequently proves injurious than beneficial. It is scarcely possible to manipulate a tin which has been varnished without cracking the varnish to some extent and producing either a slight separation of the film, or a pin hole. When this is the case, the whole of the action of any acid contained in the contents of the tin is concentrated on the one spot, and the destruction of the tin is only a question of time, and probably a short time. Another attempt was made by coating the iron with chemically pure tin by electro-deposition, in the hope that by this means any microscopical holes would be covered. In practice this did not work any better than the other plan, because the solder still furnished a second metal, so that galvanic action was set up inside the tin to as great an extent as before. In the Paris laboratory hundreds of samples of tinned foods have been examined, and the almost universal presence of both tin and lead in all classes has been strongly remarked upon.

Of dry goods, tea is perhaps the best illustration, inasmuch as not only is the flavour of the tea itself very delicate in character, but tea appears to be remarkably prone to acquire any external odour from the air in which it is placed. It is, of course, well known that tea is always packed in cases which are lined with lead. In the case of China teas the lead is tolerably pure, cast into sheets by pouring the melted metal on to one stone and dropping another stone on the top of it. This primitive method produces a sheet of somewhat singular uniformity in thickness, weighing about 2 lb. to 3 lb. to the sq. ft. Indian teas are packed almost exclusively in lead which is sent out from this country. It is not pure. It contains an admixture in most cases of tin, and sometimes a small proportion of antimony. These are added to enable the lead to be rolled much thinner, and the weight of it is not more than ¼ lb. to the sq. ft. Before any injury can occur to the tea itself this lead must be either destroyed or perforated, or at any rate it must not be in an air-tight condition. It is obvious that, except in cases of neglect, all such goods would be packed in wood which was at any rate fairly well seasoned.

Assuming that the wood has been cut for a time and is well seasoned, it is evident that if it be saturated or supersaturated with moisture for days or weeks it is brought again into a condition closely approximating to green wood as regards its moisture, and also, by an inference which seems to be founded on fact, as regards its chemical liability to decomposition. Or again, supposing that this wood has been supersaturated with moisture, a new chemical state may be introduced.

The wood itself may not only be wet in the same sense as when freshly hewn, but wet in the sense of having been dipped in water, or water having been poured over it. This specially applies to the top layer of packages in the vessel's hold, because the coldness of the deck during the night almost invariably produces considerable deposition of moisture, which is entirely evaporated again during the day. It is a matter of common knowledge that for years past numerous varieties of wood have been used for packing goods shipped here from the East, but that with few exceptions, until recently, only one kind has been used for packing tea. This is a species of wood known in this country as "toon" wood, and every one who has ever seen a tea-chest made of it must be familiar with its general characteristics. It is easily worked, does not require to be stacked long to season, is free from smell, and not very liable to absorb water. The cases of injury with this wood have been of only occasional occurrence, and appear to have been determined much more by accidental circumstances than by even an occasional failure in the character of the wood itself. But of late years the supply of "toon" wood has run short, the quantity which has been cut down for tea packages has completely destroyed some of the larger forests which used to form the leading source of supply, and the Chinese have had to resort to the use of other woods as substitutes, and in the whole of the Assam district woods are being used at random without any attempt at proper selection. Several of these woods are fairly suitable, while others are distinctly unsuitable, from their smell, and a peculiar action to which it will be necessary to draw attention.

There have been several specific cases of damage during the last 5 or 6 years, in which large quantities of tea and of several other delicate substances have been damaged, and it has been possible to make a much more complete investigation into the cause than could be made when the number of damaged packages was but small. One serious case was a consignment of Assam tea, which, instead of its proper tea flavour and smell, had a distinctive character of its own, the smell resembling a new and excessively rank kid glove. Some hundreds of chests were damaged in this way, and after inquiry it was found that for 3 or 4 seasons in succession a large portion of the tea from this particular plantation had come over damaged in a similar way, although to a less extent. The tea itself, the mode of packing it, and the temperature at which it was packed, naturally suggested themselves as the cause, but careful inquiries proved that the manipulation in the curing of the tea was just the same as in other surrounding plantations, that there was apparently no difference in the temperature of packing, and that the cause must be looked for in something further than these. A number of the chests were examined, and it was found that they were made of a mixture of different kinds of wood, one chest containing sometimes as many as 6 or 7 different species—in fact, frequently one-half the lid would be of one wood and the other half of another wood. When the wood was removed from the lead lining, the inner surface of some of the pieces was in its normal condition, nearly clean and free from smell, while other pieces were coated with a whitish powder, in some cases in quantity so small as to need a pocket lens to see it—in other cases in larger quantities, so that it could be scraped up with a finger or a card—and the lead beneath these pieces of wood which had the white powder on was found to be pitted or indented on the surface, and in cases where the action had proceeded to the fullest extent it was perforated as finely and almost as regularly as if the whole had been pricked with a needle. The lead itself was examined. It was common lead, containing only $\frac{1}{4}$ to $\frac{1}{2}$ per cent. of antimony, and quite as good as, if not superior to, a large quantity of lead which was used for other consignments in which no defici-

ency had occurred. The white powder was then collected in sufficient quantity, and found by analysis to be white-lead of normal composition, i.e. about 75 per cent. lead carbonate, 25 per cent. lead hydrate, with small traces of adhering acetic acid. This points clearly to the question which has to be decided as to the mode in which the damage has been effected. So far we have cases lined with lead, which in some parts are coated with white-lead on the exterior surface of the lead, and perforated, and in other parts are not; secondly, the coating of white-lead and the perforation for the greater part accord in position with certain pieces of wood forming part of the chest, while the less injured part of the lead accords in position with other portions of the wood forming the chest; and thirdly, we have the objectionable smell. To see in what way this is produced, we must refer to the chemical reactions which can take place.

The ordinary Dutch process for the manufacture of white-lead is so well known that it is only necessary to sketch it in outline to show its reference to this case. When tan or dung, both of which are essentially woody fibre, although in both cases containing an excess of nitrogenous matter, are exposed to moist heat, carbonic acid is generated. The generation of this carbonic acid depends upon conditions which involve the presence of moisture and a moderately warm temperature. Minute quantities of acetic acid are added in starting the stack, but the proportion is very small, less than 1 per cent. on the quantity of lead stacked, and all this is usually absorbed or combined with lead before $\frac{1}{10}$ of the lead has been corroded. It is obvious that there is no special virtue in the materials used for this Dutch process, so long as lead is exposed to an atmosphere which contains acetic acid in minute traces, and carbonic acid in very small quantity. This air, so saturated, is capable of acting upon lead and producing the effect now referred to. The sap of wood invariably contains sugar. The quantity is small, but still measurable. This sugar is, in every case that has come under observation, a fermentable sugar, and the first result of the fermentation is in most cases alcohol. Fermentation being carried a step further, free acetic acid is the natural result. With the formation of acetic acid carbonic acid is also formed, and it is a general—perhaps universal—thing that carbonic acid is generated or liberated from substances in the hold of a vessel. Transferring this from a theoretical to a practical case: A wood containing sap which was more than usually saturated with sugar, and exposed to a moist heat, would ferment more readily, would produce a larger quantity of alcohol, would consequently produce a larger quantity of acetic acid, and would therefore, by inference, derived from practical work, produce a larger amount of carbonic acid, and thence of white-lead. These effects would be produced mainly, if not entirely, upon the surface of the wood, and one of these surfaces would be in contact with the metallic lead which forms the lining of the case. Now let us see what would take place. The lead lining would be exactly in the same condition as the lead in a lead-stack which was being worked by the Dutch process. Acetic acid, carbonic acid, and moisture would all be present. There would be a reasonable and probably, in accordance with practice, a very proper degree of heat, and the lead and wood would be in contact; and it seems the most natural thing in the world to assume that, as the result, lead acetate would be formed by the direct action of the acetic acid. Lead carbonate and hydrate would be formed from this by the action of the carbonic acid and the moisture in the air, and although the two chemical changes would run on almost concurrently, yet the result would be the direct formation of a film of white-lead. Again, the white-lead having been formed, the sheet lead forming the lining has necessarily been wasted—part of it has been transformed, to put it in a plain way, from metal into paint.

The lead of which the linings of tea chests are made is never *quite* pure—such a thing would be commercially impossible. The consequence of this is that the same result takes place as in ordinary white-lead manufacture. The action of the dilute acetic acid vapour is most energetic at places where some infinitesimal particle of foreign metal offers a point of vantage for the dissolution or change. Examination of a large number of chests shows that this conjecture is true, for instead of the pitting which is invariably found in crates taken out from white-lead stacks, we have not only pitting but absolute perforation in the lead taken off from tea chests in which this action has taken place. Perforation takes the form of minute pinholes scattered all over the lead, but showing to a much greater extent on the upper surface of the package than on the lower one, thus confirming the idea that it is partly due to the condensation of moisture on the top of the packages. This gives a new result. The package is no longer air-tight, or anything approaching it, but, on the contrary, there is ample ingress for any fumes which may be given off from the wood or from any general cargo, and ample exit for the peculiar odour of the goods packed in the lead lining.

First, this perforation causes the goods packed inside the lead to be pervaded with any peculiar odour that may come from other portions of the same cargo, but obviously when the damage produced in this way is slight, it is a matter of great difficulty to tell what goods were packed in the immediate neighbourhood of the damaged packets, and in 9 cases out of 10 the cause would probably never be properly traced out. But in the other case something definite may occur. Acetic acid may be produced in minute quantities; it may act on the lead, and in so acting on the lead it is certain it would act also on the wood. Every one who has been inside a white-lead factory must be familiar with the fact that a peculiar smell is produced in the stack, and this smell, or one very closely analogous to it, is also produced by the action of this dilute acetic acid on the wood. This odour is not a general one pervading the hold of the vessel, but a special and peculiar one produced inside each chest or case, and in actual contact with the goods which the chest or case was intended to preserve. The generation of acetic acid has made the perforations, and the same generation of acetic acid will or may cause the production of a certain amount of objectionable odour, and that odour may or may not pass into the goods which are supposed to be carefully enclosed inside the wooden envelope. If ever such a small dose pass in, it is obvious that the goods may be tainted and injured. It must be borne in mind here that the objectionable smell is not that of acetic acid pure and simple, but that of acetic acid acting on wood, which produces decomposition products far more unpleasant in character.

We now come to two more effects which may be the result of the same action. White-lead having been produced, and perforation of the lead having been effected, it is not at all necessary, even assuming that damage has taken place, that the smell should have been produced by the action of the acetic acid. In the first place, some other cargo might have caused the injury; but this, although not impossible, is unlikely, because of the care which is universally taken in stowing delicate cargoes of this kind. Secondly, the wood, which has been the cause of the damage so far, may by its own inherent smell damage the contents of the cases of which it is made as to render it impracticable to use or sell them. There have been instances in which Indian tea had been packed in cases, part of the wood of which was of such a character that it was impossible that any delicately-scented article could be in contact with it for several weeks without acquiring an odour. It is, however, difficult to identify these woods accurately in this country—in fact, several of the samples already obtained are not to be found in the Herbarium at Kew;

but among the woods which have been used for the manufacture of tea chests are *Mangifera sylvatica*, or "mango wood" (which is notorious for its sour or vinegary smell), *Buchaniana*, *Holigarna longifolia*, *Erythrina indica*, and *Derris robusta*. Every one of these is either a poisonous or a stinking wood. A poisonous wood *per se* has no effect upon the subject, except that it is much more likely to change in character and so do some injury. Again, the *Pinus longifolia* was tried for some time in Upper India, in the Assam district, but that failed, because of its resinous smell. It is scarcely credible that tea growers, familiar as they presumably must have been with the general character of these woods, should have used such utterly unsuitable specimens for the manufacture of tea chests.

The action on the lead differs in different pieces of wood, and differs to some extent according to the character of the wood itself; and the action is in all cases more energetic on the top of the chest or package than on the lower part. It seems to follow from this, that although an external source of acetic acid would be quite sufficient to account for some damage occurring to chests packed in this way, it could not possibly account for the local damage which occurs, nor for the peculiar smell derived from the wood, which does permeate the contents of the package. From all this it is clear that the object of the foreign producers has been, while bringing their goods up to the highest quality, to pack them as cheaply as possible, and having exhausted their supply of suitable woods they have been using any unsuitable wood within easy reach, allowing importers in this country to bear the damage which has been caused.

The summary of the whole matter is this:—Goods such as tea must be packed in envelopes, the substance must be wholly covered, and as far as practicable it must be preserved from external effect; this substance must practically be sheet lead; and this sheet lead must be protected in some way from any such action as that pointed out. A wooden casing is suitable and right as regards mechanical protection; but if the question of chemical action arises at all, the wood must be selected with such care that it is impossible that the lead lining should be injured.

For many substances, metallic cases might be replaced by waterproof paper, as described on another page.

Possibly woods unsuitable for packing cases, where they would come into contact with metal, may be rendered harmless by treatment with a potash, soda, or lime solution, to remove all traces of free acid.

Textiles.—The packing of textile fabrics for foreign markets is a subject which has received very great attention in this country, notably in Lancashire. Much depends upon the proper packing of goods, and frequently improper packing causes great losses, owing to the severity of various climates, in one way or another. The shape and weight of packages are both important, and each foreign market, as a rule, has its special peculiarities, which must be carefully considered when purchases are made up for delivery.

The main points in packing are (*a*) to properly compress goods into the smallest possible space without damage; (*b*) to so protect them from wet and wear as to have them reach their destination in perfect condition; (*c*) to have them suit the convenience, taste, and requirements of various foreign markets; and lastly (*d*) to do all this well at the least expense.

It is essential that packing should be done so as to economise space, and thus save freight charges, and to do this it is necessary to press the bales into the smallest size possible without injuring the goods. Another important point is to have the goods packed so that a large bale can be separated into smaller complete packages, in order that they may be placed on mules or other beasts of burden, which are yet the common carriers in some countries. In the case of sized goods, there are many considerations to be kept in mind, such as the quality of the paper, the kind of cloth

for covering, and the material out of which these are manufactured. Mildew is common in sized goods, and great care is always necessary in packing the same. In fact, unless the ingredients used in the sizing are of the proper quality and quantity, some sort of growth in the bale is pretty sure to follow, no matter how well the goods are packed. There are fashions, so to speak, in packing goods for some foreign countries, notably in the South African trade, where even the colour of the iron hoops on a bale is important. There was an instance where a consignment of cloth in red hoops sold at once, but another lot of precisely the same goods could not be disposed of until the black hoops were painted red. So much for native tastes and fancies.

The ordinary bale contains 50 pieces, although as many as 500 are sometimes packed together. When goods are placed in a packer's hands, the shipper gives minute directions how they shall be put up. If the packer fails on his part, and any damages arise, he is liable for the same. Of course there are various styles of packing, and cheap goods are often imperfectly packed. It is claimed, however, by old and experienced houses that cheap packing is always, as a rule, the dearest, owing to the dangers of damage through damp and handling. Hydraulic presses are generally used in packing, and the following is the *modus operandi*, as a rule:—First, the necessary iron hoops are laid on the bed of the press, commonly 5 in number, and on these the coverings for the goods are placed in their order. The tarpaulin is cut large enough to cover the top of the bale and fold down 6 in. or more all around. The goods are laid on the coverings, and a duplicate covering is laid on top, corresponding to that on the bottom, when the bale is pressed. A piece of tarpaulin is then wrapped around the bale, wide enough to cover the portion from the top and bottom nicely, and then the ends and sides of the covering are neatly folded. The outside wrapper is then sewn up with strong twine, the hoops are riveted, and the work is done. The latest rivet used has 2 shoulders on it, and when placed in the slot cut through the hoop and turned half round it holds fast. When the pressure is taken off the bale, the hoops are so very tight that the rivets cannot well be moved.

The following methods of packing may be considered representative:—

(*a*) Best. The goods are wrapped in (1) white paper, (2) grey paper, (3) linen oilcloth, (4) brown paper, (5) patent black tar cloth, 20-porter linen, (6) brown paper, (7) outside canvas, 18-porter linen, (8) iron bands.

(*b*) Second. The goods are wrapped in (1) double grey paper, (2) jute canvas, 16 porter, (3) best brown tar cloth, 20-porter linen, (4) brown paper, (5) outside canvas, 18-porter linen, (6) iron hoops.

(*c*) Common. The goods are wrapped in (1) white paper, (2) double paper, (3) common brown or tar cloth, 16-porter jute, (4) brown paper, (5) outside canvas, 18-porter jute, (6) 5 iron hoops $1\frac{1}{4}$ in. wide.

(*d*) Commonest, for India and China goods. The goods are wrapped in (1) double grey paper, (2) common asphalt tar cloth, 14-porter jute, (3) brown paper, (4) outside canvas, 18-porter jute, (5) 5 iron hoops $1\frac{1}{4}$ in. wide.

(*e*) Recent, for India and China goods. The goods are wrapped in (1) double brown paper, (2) glazed brown paper, (3) tarpaulin, (4) common brown paper, (5) outside canvas, 18-porter jute, (6) 5 iron hoops.

These examples will furnish full details of the methods, and in large part the materials, in use here in packing goods for the different markets of the world, so far as the coverings are concerned. Some packers use white paper next to the cloth, while others use "unbleached" paper, claiming that it is purer and less liable to injure the goods. Style (*e*) of packing has been used by a large firm in Manchester for 2 years past, without a single complaint from purchasers.

For Africa.—Goods for Africa are, in large part, cased in wood and tin. They

are generally packed in small cases so that they may be easily transported on camels. The cases are 12–14 in. deep, and the width and length depend upon the size of the cloth. If the goods are heavy, what is known as German-hoop cases are used; if light goods, plain hoops are provided. A layer of ordinary brown paper is placed next to the cloth, so as to prevent the tin from soiling or rubbing it. Fine pieces are generally packed in brown-paper packages, and these are first pressed before they are placed in the tin- or zinc-lined case, so as to form as solid a package as possible. Where goods are packed in bales for Africa, much the same covering is used as in the examples already given. The cheap goods are generally packed in bales to save expense.

For India.—Small bales are the rule in this great trade. Double wrappers are generally used, and for the interior 4-fold wrappers are necessary to protect the goods from the rough usage of long overland conveyance. The paper and other wrappers are similar to the examples given.

For Australia.—For this market the largest buyers have their goods packed in zinc-lined cases. The zinc finds a ready market for roofing purposes. The covering for the goods is similar to the packing for the African trade.

For Europe.—The goods are mostly packed in large bales for these markets, about 20 cwt. each. Spain will not have small bales. All these goods are packed in single wrapper. Jute wrapper is used, but single wrapper, though rather dearer, is much the best. The difference in the cost of the two wrappers, for a bale requiring 4½ yd., is about 6*d*.

For Gibraltar.—The bales landed at this point have a covering of wood ¾ in. thick on the top and bottom of each bale, to shield it, as packages receive rough handling at this port. It has been found that this protection of wood adds to the security of the goods, and also meets the wishes of merchants who purchase them.

For River Plate.—Specially small packages are made up for this trade, as they are transported hundreds of miles on mules, and these average about 80 lb. in weight. They are some 3 ft. long, 2½ ft. wide, and 8 in. thick; 3 iron hoops are used, and the covering is similar to (*d*) heretofore given; 2 of these packages are carried by each mule, one on each side.

Wrapper or Canvas and Tarpaulin.—Wrapper is of different qualities, and is described as 6, 8, 10, 12, 14, 16, 18, and 20 porter wrapper. The term "porter" indicates the number of threads to the inch; 16-porter wrapper meaning 16 threads to the inch, and so on. The larger the numbers the closer and finer it is, 16 being the popular wrapper in general use. The wrapper is 32, 36, 40, 45, 50, 60, and 72 in. wide, and has to be selected according to the width of the goods to be packed and the intended size of the bale. Very little of 60 and 72 is now used, but the packer must always keep these widths in stock. The tarpaulin need not be above 50 in., which is the maximum. If it is too narrow to cover a bale, a slit can be cut to cover the same. There are 3 widths for tarpaulin, viz. 36, 40, and 50 in. Both wrapper and tarpaulin should be kept on rollers, where they keep softer, and the latter more pliable.

There are various preparations used in the production of tarpaulin, and almost every manufacturer has his own special mixture. Among the many named are the following:—5 parts Stockholm tar pitch melted with 4 of rosin and 1 of Stockholm tar; 48 parts Stockholm tar pitch, 10 Stockholm tar, 32 rosin, and 1 tallow.

Special attention must be called to the necessity of having thick packing paper, in double sheets, placed between the tarpaulin and cotton goods, where the tarpaulin had been made with the pitch of cotton-seed and other oils, as damage to the goods would take place unless this precaution was observed.

The cost of tarpaulin in Manchester is as follows: 36 in. wide, 3¾*d*. per yd.; 40 in. wide, 4⅛*d*. per yd.

Iron Hoops.—The best hoops cost 9*s*.

to 9*s.* 6*d.* a cwt., cut to the desired length, and painted such colours as may be desired.

Paper.—Turner's patent packing is much used here as a substitute for paper. It is strong, and answers its purpose very well. The prices are as follows: 22½ in. wide, 1⅜*d.* per yd.; 28 in. wide, 1⅝*d.* per yd.

Twine.—The twine used in sewing up the bales should be finished in tallow, as this is much the best. Jute stitching-twine is generally used here, but cotton twine is stronger and better. It never gets hard, and is more pliable than jute. A good twine costs here 10*s.* 6*d.* per doz.

German packing.—For the packing of woven goods in Germany the following precautions are taken. The fabric is first folded on thin wooden board, then wrapped in white paper, then again in blue paper, then labelled, and put in pine cases, the corners of which are sealed with pitch so as to render them water-tight. Tin was formerly used for this purpose, but pitch has proved cheaper and equally serviceable.

Common braids are generally wound up in pieces, each containing 36 yd., wrapped in yellow or brown paper. A small piece as sample is placed on the outside of each package and the trade-mark pasted on. Four packages, containing 144 yd.—a gross—are placed in a carton, and then the whole tightly boxed up, so as to prevent movement during the transport. Finer qualities of braids, such as mohair, and genappe, are commonly reeled on slats or paste-board, covered with blue or red glossy paper; a fine tissue paper, generally a white one, with the trade-mark pasted on it, is wrapped around the braid, so as to keep it from rubbing, and giving it a fine appearance at the same time. These braids are likewise placed in elegant cartons, lined with yellow English leather, also by the gross, and then boxed up.

Common trimmings, such as rick-racks, &c., are commonly put up in bunches containing 12 yd. each, simply tied with a red cord, the trade-mark adjusted in the centre of the bunch, and the whole is wrapped up by the dozen in blue paper. Common bindings are put up in a similar manner, but are uniformly packed in gaudy cartons. Finer trimmings and bindings undergo the same process in packing as the finer braids. Common bands are reeled by 500 yd. on bobbin, and yarn is put up in skeins by the pound. These goods, when consigned to parties within the "Zollverein," and to neighbouring countries, such as France, Belgium, Netherlands, Switzerland, and Austria, are generally packed in simple wooden cases. Goods consigned to remoter countries, such as Italy, Spain, Russia, and Turkey, are frequently wrapped up in strong varnish paper; and, when shipped to the United States, are generally enclosed in oil-cloth so as to keep off dampness, and then put in wooden cases. Similar shipments to Mexico or the South American States are mostly encased in tin boxes, and, after being soldered, these are placed in wooden boxes. It may, however, be remarked that, as a rule, German exporters do not excel in packing, and are rather careless and deficient in this important trade appliance.

French Packing.—Goods for long voyages are usually packed in this manner: A strong box is made from 1-in. boards, being in length and breadth inside about the same as the length of the goods to be packed, and of any required height. The box is then lined with sheets of tin, cut so as to fit the box closely. The seams of the tin are then carefully soldered on the bottom and sides so as to be water-tight, after which a lining of coarse, cheap cloth, or other substance, is placed inside in order to keep the goods from being damaged by rubbing or chafing. The goods are then packed in firmly, each piece being wrapped in paper, and each alternate layer being placed crosswise of the other until the box is full, when a like protection of cloth or other lining is placed over the top of the goods. Then the tin cover is put on and carefully soldered at the seams where the tin is joined, making the whole perfectly

water-tight. The top of the wooden box is then put on, and the goods are ready for shipment. It is claimed that goods packed in this manner may be shipped to the most distant countries without danger of being in the least damaged by shifting, chafing, or from the elements. In fact, it would seem quite impossible for the goods to receive damage, even if they were to encounter rough handling or be quite immersed in water by reason of boisterous weather at sea. As the tin lining of the box is available but for the one shipment, it is only necessary to use light, cheap tin. The tin lining may be properly designated as a tin box to be placed within a closely-fitting wooden box or case in which to pack goods for shipment, and for the sake of convenience may be constructed separately so as to be ready for use when wanted, and placed within the wooden box or case when the goods are required to be packed.

For shorter and less dangerous voyages, goods are usually packed in square-shaped, coarse sacks, around which is placed wheat, rye, or oat straw, and around this is placed still another sack of strong material. Frequently the outer protection in this mode of packing is simply an open box, made from strips of board 3 or 4 in. wide and about the same distance apart, and being fastened to a square frame at either end. These boxes, or more properly crates, are rough and cheaply though strongly made, and are used for the purpose of keeping the straw in place around the sack and the goods from being damaged. The sacks used in this manner of shipping are returned by the consignee to the shippers, and may be used until worn out. This process of packing is used only in inland transportation, and appears to be convenient, and to have the advantage of a great saving in wood over the large and cumbrous dry-goods boxes one is accustomed to see in America.

Ice.—The storage of ice in large quantities is a matter demanding some skill and experience in the construction of the "house." The following directions are given by various authorities.

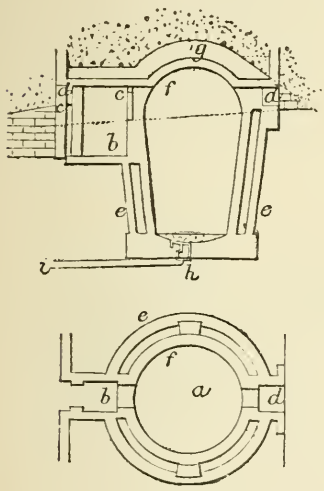
(1) Build round a brick well, with a small grating for drain at bottom for the escape of water from melted ice. Cover the bottom with a thick layer of good wheat straw. Pack the ice in layers of ice and straw. Fix a wooden cover to the well.

(2) Fire-brick, from its feeble conducting power, is the best material to line an ice-house with. The house is generally made circular, and larger at the top than at the bottom, where a drain should be provided to run off any water that may accumulate. As small a surface of ice as possible should be exposed to the atmosphere, therefore each piece of ice should be dipped in water before stowing away, which, by the subsequent freezing of the pieces into one mass, will remain unmelted for a long time.

(3) Make a frame-house the requisite size, with its floor at least the thickness of the bottom scantling from the ground, thus leaving space for drainage and a roof to shed off the water. The boards of the wall should be closely joined to exclude air. Then build up the blocks of ice, cut in the coldest weather, as solid as possible, leaving 6 in. all round between them and the board walls; fill up all interstices between the blocks with broken ice, and in a very cold day or night pour water over the whole, so that it may freeze into a solid block; shut it up till wanted, only leaving a few small holes for ventilation under the roof, which should be 6 in. above the top of the ice. It is not dry heat or sunshine that is the worst enemy of ice, but water and damp air. If all the drainage is carried promptly off below, and the damp vapour generated by the ice is allowed to escape above, the column of cold air between the sides of the close ice-house and the cube of ice will protect it much better than it is protected in underground ice-houses, which can neither be drained nor ventilated; sawdust also will get damp, in which case it is much worse than nothing.

(4) An improved sort of ice-house, recommended by Bailey, gardener at Nuneham Park, Oxford, is shown in plan and section in Fig. 6, where the dotted line indicates the ground level.

Fig. 6.



The well or receptacle for the ice *a* is 10 ft. 6 in. wide at the base, and 3 ft. wider near the top; the walls are hollow, the outer portion being built of dry rough stone, and the inner wall and dome *f* of brick. The outer wall *e* might be replaced by a puddling of clay, carried up as the work proceeds. Over the top is a mound of clay and soil *g*, planted with shrubs to keep the surface cool in summer. The drain *i* carries off the water formed by the melted ice, and is provided with a trap *h* to prevent the ingress of air through the drain. There is a porch or lobby *b* provided with outer and inner doors *c*; and apertures at *d*, to get rid of the condensed moisture, which, if not removed, would waste the ice. These ventilating doors should be opened every night, and closed again early in the morning. The most important conditions to be secured are dryness of the soil and enclosed atmosphere, compactness in the body of ice, which should be broken fine and closely rammed, and exclusion as far as possible of air. (*Gard. Mag. Bot.*)

(5) A very cheap way of storing ice has been described by Pearson of Kinlet. The ice-stack is made on sloping ground close to the pond whence the ice is derived. The ice is beaten small, well rammed, and gradually worked up into a cone or mound 15 ft. high, with a base of 27 ft., and protected by a compact covering of fern 3 ft. thick. A dry situation and sloping surface are essential with this plan, and a small ditch should surround the heap, to carry rapidly away any water that may come from melted ice or other sources. (*Gard. Jl.*)

(6) The following is an economical method of making small ice-houses indoors:—Dig a hole in a cool cellar, and make it of a size corresponding to the quantity of ice to be kept. At the bottom of this hole dig another of smaller diameter, the edge of which goes down with a gentle slope. This kind of small pit, the depth of which should be greater in proportion as the soil is less absorbent, must be filled with pebbles and sand. The whole circumference of the large hole is to be fitted up with planks, kept up along the sides with hoops, to prevent the earth from falling in. Then the bottom and all the circumference of this sort of reservoir must be lined with rye straw, placed upright with the ear downwards, and kept up along the planks by a sufficient number of wooden hoops. The ice is to be heaped up in this ice-house, which must be covered over with a great quantity of hay and packing cloth, on which should be placed a wooden cover and some light straw. (*Les Mondes.*)

(7) As the result of 14 years' practical experience as the proprietor and lessee of salmon-fisheries on the west coast of Scotland, and having devoted a considerable time to the careful study of the various modes hitherto generally observed by fishermen and others, not

only on the west coast, but in many other parts of Great Britain, for preserving ice, Maclean has found that although sometimes elaborately constructed, at great expense, the houses used for this purpose often prove entire failures. Some simple flaw in the construction renders them practically useless to serve the purpose for which they are intended. As a rule, he has found that about $\frac{7}{8}$ of the ice stored in these houses goes to waste, and, in many cases, it altogether disappears; but, of course, there are exceptions. After several trials of various methods which he thought likely, in some measure at least, to prevent this waste, he discovered that nothing can compare with the kind of ice-house now in use at his fisheries, which is shown in Figs. 7, 8, 9. The total expense of providing one of these peat-houses need not exceed 50*s.*, and the cost of the others will not, under ordinary circumstances, be greater than between 7*l.* and 8*l.*—a very small sum when compared with the amount of money expended on the houses generally used for the preservation of ice. The advantages to be gained by adopting Maclean's plan will be an incredible saving of time, labour, material, and, consequently, of expense, combined with a comparatively small waste of ice, thus putting within the reach of fishermen and others of limited capital, a cheap and useful means of conveniently storing and preserving any quantity of ice.

FIG. 7.

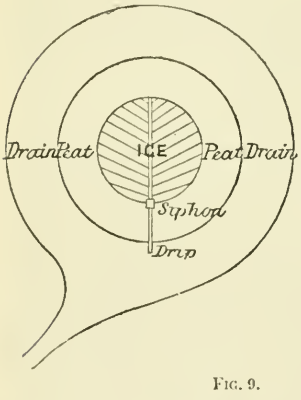


FIG. 8.

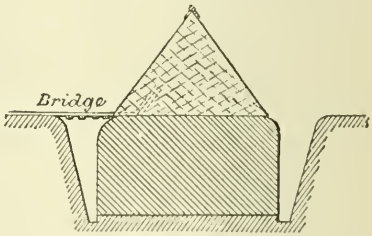
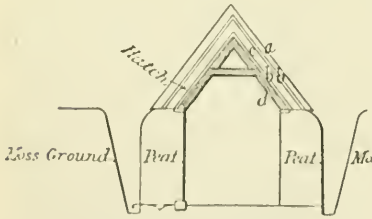


FIG. 9.



In preference to one or more large houses, Maclean makes choice of several small ones—each of them capable of holding, say, about 20 tons—because he finds that, an ice-house once opened, its contents, exposed to the atmosphere, are more liable to waste than the ice in one which has not been opened. The advantage of adopting the smaller houses will thus at once be seen; the opening of one exposes but a small quantity of ice at a time. Again, these houses can be rapidly filled, and should one, through any cause, fail to serve its purpose, there are others to fall back upon. These remarks apply to his own peat-houses only, which are constructed on the following principle, being the most useful to meet the requirements of his fisheries, which, previous to the extension of the railway to Oban, were

difficult of access to the market. Having selected a peat-moss of the required depth, convenient to a road, and near the margin of a small sheltered lake, he marks out the ground to the dimensions shown on Figs. 7, 8, 9 for the interior of the house; the divots removed from the surface are placed in a circle round the edge of this space so as to strengthen and protect it during operations. Six men in a few hours can make the necessary excavations: two are employed clearing out the space required for the storing of the ice; one to cart; one to assist in filling the cart from the *débris*, and two are employed in cutting the drains; a seventh man is simultaneously engaged in preparing the roof. The space intended for the ice being completed, the whole of the men, except the one preparing the roof, join in making the drain. By the time the drain is half finished the supports for the roof are put up. These are made of rough pieces of oak, and rest on barrel staves placed at the required intervals across the top of and at right angles to the wall. The spaces between the couplings are filled up with hazel or oak branches about 2 in. thick; a layer of divots, heather side inwards, is now put on; over that is laid a coating of the best and softest moss taken from the drain and tramped into a solid mass all over the roof to a uniform thickness of 15 in. After this, another layer of divots is put on, heather side out, and the whole is covered with straw or heather-thatch to the thickness of 2 in., and secured with heather-rope or coir in the usual way. The apex is protected from destruction by birds by covering it with a piece of old tarpaulin to the breadth of 15 in. The drains are dug 1 ft. below the level of the floor of the house. A hole is cut in the north side of the house to admit of a siphon being placed in it. Small drains, as shown in Fig. 7, are cut, and the siphon —which Maclean has found to answer well in the peat, and which is made of indiarubber tubing 1–1½ in. diameter, and lashed to a bit of iron bent to shape and served over with marlin—is placed. It has a bell-shaped mouth-piece made of wood or metal, with a rose covered over with a small wooden-perforated box to protect it from injury. If, by any chance, it is noticed that no drainage is coming from the house, or that the water is exhausted by evaporation, it is well to attach a small piece of leather over the nozzle of the siphon, which, when the wind blows against it, acts as a valve. A few branches placed in the bottom will keep the drains clean, and the filling of the house may at once be proceeded with. The ice should always be broken up into as small pieces as possible, well packed, and salted with snow. When the house is filled to about 1 ft. above the level of the walls, pack the remaining space with sawdust.

As there are many places where peat cannot always conveniently be found, Maclean would, as the next best means of preserving ice, recommend it to be

FIG. 10.

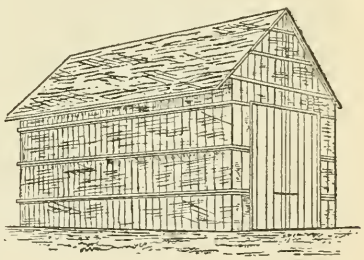
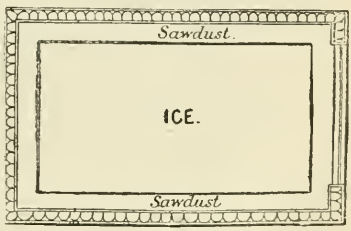


FIG. 11.



stored in a house constructed on the plan shown in Figs. 10, 11:—Drive pieces of split larch of the required

height into the ground, so as to enclose a sufficiently large space, and place them as close to one another as possible, any rough edges being previously cut off. Tie them inside and outside by strong rafters of the same material in a horizontal position—3 will suffice in ordinary cases; line the inside of the structure with rough sarking boards, filling up the crevices with sawdust well rammed in courses corresponding to the depth of the sarking boards all along to and underneath the baulks; thatch in the usual way with turf and straw or heather; put a coating of coal-tar outside the sides of the house, and give the floor a gradual slope towards the door; cut a drain round the outside to carry away the surface water and any waste that may take place. A space of 1 ft. to be packed with sawdust should be left between the ice and the wall, and filled up gradually as the ice is being stored. The space immediately inside the door should be carefully and tightly packed with sawdust: the small door made in the larger one admits of this being easily done. A house of this kind costs between 7*l.* and 8*l.* The letters on the roof indicate as follows:—*a*, thatch; *b*, turf; *c*, tramped peat; *d*, rough rafters.

(8) The old-fashioned plan of storing ice under ground was assuredly a good one, but had the disadvantages of occasionally being impracticable, from the character of the subsoil, and always expensive.

An ice-house, to be thoroughly efficient, need not be under ground. The chief requirements of such storage are that it be formed of non-conducting materials, so far as heat is concerned, and so constructed as to give easy access, and drainage, without unduly admitting the external air. Added to these, and the better to ensure an extended sphere of usefulness, low first cost must be mentioned.

These indispensables to the modern ice-house, in Ross's opinion, are happily not far to seek. In wood we have the first requirement admirably met, while its adaptability and cost leave nothing to be desired; and, if care be exercised in the selection of the kind of wood used, and in its subsequent preservation by an occasional coat of paint, it will prove to be by no means the ephemeral material many suppose. The sole remaining difficulty is the design of the structure. So far as surroundings are concerned, a shaded situation is preferable, but not indispensable; and as for the external elevation, it can be modified to meet the taste and purse of the owner. By adopting any of the many modifications of the circular form, the ventilation is the better assured, while the cost is not in any degree enhanced.

The entire floor, extending at least 1 ft. beyond the exterior of the walls, should be of thoroughly laid concrete, not less than 1 ft. above the surrounding level, attention being given to have foothold for the wall-posts and slope from the centre for drainage. By this form of floor we guard against excessive terrestrial radiation and vermin.

The walls can be raised with any required number of angles, and the structure may range from a pentagon upwards. They must be double, with an interspace of 18 in. at least, and of sound pitch pine,—the interspace to be filled with the most efficient and cheapest non-conductor we have, viz. sawdust. Two doors are needful, one in each wall, and they must fit pretty tightly. The roof must be lined internally on the couples, and the interspace filled with sawdust as before. Felt is preferable as a roof covering, and the apex of the roof must be of the "Lutther" class of ventilator. The whole exterior to have 3 coats of best silicon white paint. For drainage, surface gutters in the concrete, radiating from the centre, and having trapped termini debouching at the underside of the concrete.

The house finished, it has to be filled. This is best done by pounding down the ice, from whatever source derived, packing it closely in, and ramming it well together as it accumulates.

To use ice economically is at all times a desideratum, but so long as the stores

secured in the country are meagre, economy in its use is imperative on all. For economical purposes in general, the modified "Tube Cold Chamber" answers all requirements best. Externally of wood, with a double wall, and door in the front side, it stands for ordinary family use about 4 ft. high on corner supports 9 in. high. The wall interspace is filled with sawdust, and internally it is fitted around the walls and raised roof with U-shaped tin tubes 1½ in. internal diameter, placed about 5 in. apart, and extending down each wall and across the floor. Each has a small tap at the lowest point and communicating directly with the outside for drainage. They are filled with pounded ice, and simply corked at the mouths, which project through the tops for convenience.

The bottom of the chamber is fitted with bottle-bins for wine, and the remaining space is shelved throughout. The shelves extend to and touch the tubes, but no farther, thus affording sufficient intercommunication for the equalisation of the temperature. Ventilation is provided by air-ducts secured with wire gauze at the bottom and extreme top of the cover. The upper ventilator can be protected by lapped cover raised 1 in. from the top.

This refrigerator also forms an extremely effective ice-bin for family storage of small quantities of ice. The tubes are of course not then required, and it is better to line the bin throughout its interior with best galvanised iron and to have trapped drainage in the bottom

The cost of the ice-house, as described, for an hotel or large establishment, would not exceed 30*l*. For smaller families, from half that sum. The refrigerator, on a scale suited to the first-mentioned classes, would cost from 5*l*., smaller sizes, from 2*l*. 10*s*. The bins for temporary storage from 10*s*. upwards.

EMBALMING.—This article relates to the embalming of human corpses and the preservation of anatomical specimens. It may be taken as supplementary to the article on Preserving, in the 2nd Series of 'Workshop Receipts.'

It has been remarked by Dr. B. W. Richardson that the ancient methods of embalming, when compared with the present, were singularly rough and laborious; yet in those ancient plans are to be found the principles of preservation carried out in perfection, rudely, but perfectly. The Egyptian embalmers commenced proceedings by extracting the brain of the dead person from the cavity of the skull, through the nostrils, by means of a hook, and by the pouring of infusion of certain drugs into the cavity of the skull. In these ways they removed the brain without disfiguring the head or face. The abdominal cavity was next opened with a sharp Ethiopic stone, and the intestines were taken out.

After the cavity of the body was emptied of its natural contents, it was charged with powder of pure myrrh, cassia, and other perfumes, but not frankincense. The body was then sewn up, and covered with nitre and natron for 70 days. At the end of that period, the body was removed, washed, and closely wrapped in bandages of cotton dipped in a solution of gum arabic, which the Egyptians used as glue. It was now returned to the relations, who enclosed it in a case of wood. Pettigrew, who unrolled many mummies, is of opinion that, before the bandaging was carried out, the cuticle or scarf skin of the body was peeled off, the nails being carefully preserved. The nails were sometimes gilded; these nails and the hair were well preserved. A second and less expensive process was performed without emptying the cavities of the body at all. The intestinal cavity was injected with cedar oil, and the whole body was afterwards covered with nitre for 70 days, as in the first instance. The third and least expensive process was simpler still. The inside of the body was washed with a solution called syrmaea, and then the body was covered with natron for 70 days. The nature of syrmaea, or, as some spell it, surmia,

is not known. It was probably an aromatic solution.

Herodotus tells of another mode of preserving the bodies of the dead. He says of the Macrobian Ethiopians that they extracted the moisture from the bodies of the dead, and then, covering each body with a kind of plaster, they decorated the plaster with various colours, so as to imitate the dead as closely as possible. Then they enclosed the form in a hollow pillar of crystal, and placed it for 12 months in their houses. The process led to the story of preservation of dead in pillars of crystal.

Upon these ancient methods of embalming no marked improvements were made, as far as we know, until quite modern times, although there were great variations. The Guanches, who lived on the Canary Islands, washed the body for 4 days with water, anointed it afterwards with butter, and covered it with a powder composed of a dust of pine trees and brushwood, called "bressors," with pumice. Finally, they wrapped the body up in leather, and placed it in a cave. A specimen of a body preserved by this plan is in the museum of the Royal College of Surgeons.

Preservation of the dead by the simple process of drying, or desiccation, was practised by some communities. The Peruvians desiccated the bodies of their dead in sand. In Palermo, a convent of Capuchin Friars suspended numbers of desiccated bodies of their fellows in galleries. Captain Smythe, who visited the convent in 1624, reported that the bodies of 2000 had been so preserved in the convent. A few years ago some bodies that had been long preserved by desiccation were exhibited in London. In our modern days the process of desiccation has been very skilfully and practically applied for the temporary preservation of the dead. Falcony is the inventor of this plan, which consists in the temporary burial of the dead in a fine sawdust, charged with a salt which has a great affinity for water. Zinc sulphate is the salt that answers the purpose best. In cases where those who have died from infectious disease, cannot be at once buried, Falcony's plan serves an all-important hygienic purpose. It is also most practical in instances where deceased persons have to be removed some distance for burial, or where other circumstances demand a delay in interment.

The Burman priests used for embalming purposes methods which varied but little from those of the Egyptians. They removed the contents of the abdomen, charged the cavity with spices, and covering the body with wax or rosin, finally gilded it. In the monastery of St. Bernard, so well known to travellers, the bodies of dead persons who have died in the mountains from cold are preserved by 2 natural processes, (*a*) extreme cold and (*b*) slow loss of water—desiccation. These bodies are free of putrefactive changes, but they lose form and become shrunken from the loss of water.

If, now, we consider the lesson that has been taught by the embalmer's art, we learn that 3 distinct methods of preservation were thereby discovered—namely, preservation by the employment of antiseptic substances; by the plan of removing water—desiccation; by the action of cold. Up to the present day no new principle has been added to the art, it has been improved in its details, but on the same bases.

It was not until the time of the anatomist Ruysch, who was a contemporary of Peter the Great, that any important change of detail was introduced. Ruysch conceived the plan of injecting preservative fluids into the dead body by the blood vessels. The plan has been adopted for another purpose of late years, as if it were a new invention: it is not new at all. Ruysch carried the art of preserving by injection to such perfection that his specimens were the wonder of the time in which he lived.

William Hunter followed Ruysch in the plan of passing a preservative fluid into the dead body by the blood vessels.

He injected by the arteries, selecting generally the large artery in the thigh, called the femoral, for the vessel into which to insert the nozzle of the syringe. His preservation of the body of the wife of the eccentric Martin Van Butchell was one of the curious events of the latter part of last century. The embalmed remains of the lady are still retained in the museum of the Royal College of Surgeons, and prove that the embalmment, which was rather a prolonged and complicated affair, was successful in preventing putrefactive decomposition. The formula for Hunter's embalming solution is—1 pint Venice turpentine, 2 fl. oz. lavender oil, 2 fl. oz. rosemary oil, 5 pints turpentine oil.

When Dr. Richardson was making a visit to Paris in 1867, he was shown portions of a lady which had been preserved by some process which had never been revealed. From the general appearances he came to the conclusion that the secret preservative used in this case was nothing more than sulphuric acid, and he afterwards made some experiments of injecting the vessels of a dead animal with sulphuric acid slightly diluted, which showed him that the supposition was perfectly correct. The muscular structure in these instances seems as if it were partly charred, but it remains quite flexible, owing, probably, to an after absorption of water by the acid from the atmosphere. For the purpose of embalming, this process, as it now stands, is inapplicable; but if by any means the muscles preserved by it could have a fleshy colour communicated to them, it would be an invaluable method to the demonstrator of anatomy, since by its means he could preserve careful dissections of the natural parts for many years, ready at any moment for demonstration.

In 1854, Dr. Richardson made the observation that if liquid ammonia were brought into contact with dead animal structures, it would hold them for a long time in a state of perfect preservation. In this way, in a closed box, he preserved for a great many months numerous finely dissected specimens, and used them from session to session for purposes of demonstration. He also injected ammonia into the vessels of dead parts, in order to make it applicable as a preservative; but he does not think it would answer as a fluid for embalming so well as some other fluids, although for temporary preservation it leaves little to be desired.

Simple wood vinegar has been used by some embalmers for injection of the vessels. This application came from an observation made in 1833 by the distinguished chemist Berzelius, who examined a body that had been kept by this means in perfect preservation for 20 years.

At the time when Gannal's process was before the Academy of Medicine, Sucquet presented a preservative solution for embalming that was free of arsenic. It was a solution of zinc chloride. Experiments were made by the Academy with this solution, and with Gannal's aluminium sulphide and chloride solutions. Two bodies were embalmed, one by Sucquet's, the other by Gannal's process. The bodies were buried for 14 months, with favourable results.

The Brunetti method for the preservation of the dead consists of several processes:—(1) The circulatory system is cleared thoroughly out by washing with cold water till it issues quite clear from the body, occupying 2 to 5 hours. (2) Alcohol is injected so as to abstract as much water as possible; occupies about ¼ hour. (3) Ether is injected to abstract the fatty matters; occupies 2 to 10 hours. (4) A strong solution of tannin is injected; occupies for imbibition 2 to 10 hours. (5) The body is dried in a current of warm air passed over heated calcium chloride; may occupy 2 to 5 hours. The body is then perfectly preserved, and resists decay. The Italians are said to exhibit specimens which are as hard as stone, and retain the shape perfectly, and are equal to the best wax models.

A fluid for the preparation of animal and vegetable tissues, which surpasses anything before known in its power of preserving the colour, form, and elasticity of specimens treated with it, has been invented by Wickersheimer, of the University of Berlin. The fluid may be injected into the veins of the body to be preserved by it, or the entire object may be immersed in it. In either case the elasticity of the tissues and the flexibility of the joints are preserved. At a recent meeting of the Philadelphia Academy of Natural Sciences, Prof. Barbeck described a number of preparations which showed beautifully the combined movements of the chest, larynx, and other parts engaged in the mechanism of breathing. Several snakes which had been treated with the fluid more than a year previously permitted of undulatory and spiral movements. Lungs thus prepared may, even after years, be inflated by means of bellows. Such old lungs were seen to swell to 10 times their size in the collapsed state, the lobes became distinct, the brown colour gradually changed into red, and the whole organ appeared as if taken from a fresh body. Sections of delicate tissues, morbid formations which have been removed by an operation, will appear after months as if in a fresh state, and may thus be preserved for future study. All sorts of vegetable organisms may also be preserved in this fluid. A colony of exquisite fresh-water algæ, which had been in the fluid for a year, appeared to be growing in the water. The Prussian Government has purchased this valuable discovery, and the Minister of Instruction has published it in his official organ for the benefit of the scientific world. The formula for the preparation of the fluid is as follows: In 6½ pints boiling water, dissolve 3½ oz. alum, 6 dr. common salt, 3 dr. saltpetre, 1¾ oz. potash carbonate, 2½ dr. arsenious acid. After cooling and filtering, add to every 10 pints of the solution, 4 pints glycerine, and 1 pint methylic alcohol. The method of application differs according to the nature of the objects to be preserved. Anatomical preparations that are to be preserved dry are immersed in the fluid for 6 to 12 days, according to their size, then taken out and dried in the open air. Hollow organs, such as lungs, &c., must be filled with the preserving fluid, then laid in a vessel containing the same liquid, and afterwards distended with air, and dried. Small animals, such as crabs, beetles, lizards, frogs, &c., if the natural colours are to be preserved unchanged, are not dried, but put immediately into the preparation. The same fluid may be used for the purpose of preserving human bodies during transportation, or even for more permanent embalming.

Depérais has proposed a process for disposing of dead bodies so as to guarantee the destruction of causes of infection without resorting to cremation. His process is based on the statement that at 223° F. (106° C.) all pernicious germs are destroyed. He utilises the well-known fact that saline solutions do not boil until after the boiling-point of water has been passed. The salt he employs is calcium chloride, on account of its cheapness, the ease of its management, and because it is antiseptic and tanning in its effects. On plunging a corpse into such a solution at 96½° Tw. (47° B.) and slowly raising the temperature of the bath, it is evident that when the temperature passes 212° F. (100° C.) the water of the flesh and tissues will evaporate. Continuing the heat, the body contracts and the calcium chloride impregnates it. The prolonged bath kills the disease spores, and the hardening and antiseptic properties of the salt partially embalm the body; as, however, calcium chloride is deliquescent, the body would not dry on removal from the bath. It is removed by immersion in a bath of soda sulphate, by which the lime salt remaining in the body and incrusting all its fibres becomes lime sulphate, and sodium chloride is free in the bath. Then the body is dried either in the open air or in an oven.

If the object be not so much to embalm or preserve a whole body, as

to preserve animal tissues or anatomical or histological specimens, so that they may be transported or shipped in any climate, and be in good condition for subsequent microscopic examination, the following method, communicated by Professor Welch, of Bellevue Hospital Medical College, will answer :—Portions of the organs should be cut into small pieces (on the average, cubes about 1 in. in diameter), and placed for 4 to 8 weeks in Müller's fluid. A large quantity of the fluid should be used, and it should be frequently changed for the first week, until it remains clear. After about 6 weeks the specimens are removed from the Müller's fluid, and for 3 or 4 days are thoroughly washed in frequently-changed water, until the water ceases to become yellow after standing some hours over the specimens. The specimens are then placed either in alcohol, or in a mixture of 2 parts alcohol and 1 water, and after a few days are ready for cutting for the microscope. The spinal cord is cut into pieces about $\frac{3}{4}$ in. long, which remain connected by the membranes, and can be hardened in the above manner, but should not, as a rule, remain longer than a month in the fluid. Small pieces can be hardened rapidly in strong alcohol. Here it is necessary to take pieces about $\frac{1}{2}$–$\frac{3}{4}$ in. in diameter, and to use a large quantity of strong alcohol. The chief errors are, not using a sufficiently large quantity of the hardening fluid, or in attempting to harden too large pieces. It is best to use at least 1 pint (and preferably more) of the Müller's fluid for 6 or 8 of the cubes 1 in. in diameter, and to change this fluid several times. The specimens should be obtained as freshly as possible from the autopsy. Well-stoppered glass vessels should be used for the hardening. After the specimens are once hardened by the process described, they can be preserved in a small quantity of alcohol, and can be sent packed in cotton-wool soaked in alcohol. The Müller's fluid alluded to is described below.

Of the solutions employed for preserving anatomical specimens, the best known are as follows :—

Babington's,—1 pint wood naphtha, 7 pints water.

Burnett's,—1 lb. zinc chloride, 1 gal. water ; immerse for 2–4 days, and then dry in the air.

Morell's,—14 oz. arsenious acid, 7 oz. caustic soda, 20 fl. oz. water, and sufficient carbolic acid to produce opalescence when the mixture is stirred ; add water to make up to 100 fl. oz. Used for general disinfecting and embalming purposes.

Müller's,—2–2½ oz. potash bichromate, 1 oz. soda sulphate ; add water to make up to 100 fl. oz.

Passini's,—1 oz. mercury chloride, 2 oz. sodium chloride, 13 oz. glycerine, 113 fl. oz. distilled water.

Réboulet's,—1 oz. saltpetre, 2 oz. alum, 4 oz. calcium chloride, in 16–20 fl. oz. water ; dilute according to need.

Seseman's.—Dr. Seseman states that a corpse may be made to retain the natural form of expression for months by (*a*) injecting into it a solution consisting of 4–5 per cent. of aluminium chloride dissolved in a mixture of 2 parts alcohol of 90 per cent. and 1 part glycerine ; (*b*) painting the entire epidermis with vaseline. The quantity of liquid required for injection is in the proportion of $\frac{1}{10}$ to $\frac{1}{7}$ of the weight of the corpse.

Thwaites',—1 oz. spirit of wine saturated with creosote, rubbed up with chalk into a thin paste, and 16 oz. water gradually added.

Von Vetter's,—7 oz. glycerine at 36° Tw. (22° B.), 1 oz. raw brown sugar, and ½ oz. nitre ; immerse for some days.

LEATHER POLISHES.—Most leather articles while in use require the periodical application of a preservative varnish to give them a finished appearance, and protect them from decay and surface wear. Such varnishes go by various names, e. g. "dubbing," "gloss," &c., but are most commonly known as "blacking," being usually intended to give a black polish. Blacking is a pasty compound used especially on

the "uppers" and the edges of the soles and heels of boots and shoes. There are numerous methods of manufacturing this substance; but in nearly all, the base is a black colouring matter, usually animal charcoal, mixed with substances which acquire a gloss by friction, such as sugar and oil. The carbon employed should be in the form of a very deep, finely powdered black. Since it always contains lime carbonate and phosphate, it is treated with a mineral acid in order to decompose these salts; a mixture of sulphuric and hydrochloric acids is frequently used, the salts produced being lime acid phosphate, sulphate and chloride. The lime sulphate gives consistence to the pasty mass, and the two other salts being deliquescent help to keep the leather flexible. No more acid should be used than is sufficient to decompose these salts, or the leather will be destroyed. It is probably to prevent this that some makers add a small quantity of alkali to the blacking. Sometimes powdered gall-nuts, iron sulphate, indigo, and Prussian blue are incorporated with the blacking in order to impart to it a good colour. Fatty or oily matters are also sometimes added in order to preserve the flexibility of the leather, and to neutralise any excess of acid which may remain. The consistence of different blackings varies widely.

Liquid.—(1) The well-known liquid blacking of Day and Martin is composed in the following manner. Very finely ground animal charcoal, or bone-black, is mixed with sperm oil till the two are thoroughly commingled. Raw sugar or treacle, mixed with a small portion of vinegar, is then added to the mass. Next a small measure of dilute sulphuric acid is introduced, which, by converting into sulphate a large proportion of the lime contained in the animal charcoal, thickens the mixture into the required pasty consistence. When all effervescence has subsided, but while the compound is still warm, vinegar is poured in until the mass is sufficiently thinned; then it is ready to be bottled for the market.

(2) Animal charcoal, 5 oz.; treacle, 4 oz.; sweet oil, $\frac{3}{4}$ oz.; triturate until the oil is thoroughly incorporated, then stir in gradually $\frac{1}{4}$ pint each vinegar and beer lees.

(3) Animal charcoal, 1 lb.; sperm oil, 2 oz.; beer and vinegar, each 1 pint, or sour beer, 1 qt.

(4) Bryant and James's indiarubber blacking. Indiarubber in very fine shreds, 18 oz.; hot rapeseed oil, 9 lb. (1 gal.); animal charcoal in fine powder, 60 lb.; treacle, 45 lb.; gum arabic, 1 lb., previously dissolved in vinegar, No. 24 strength, 20 gal. The mixture is triturated in a colour-mill until perfectly smooth, then placed in a wooden vessel, and sulphuric acid is added in small successive quantities amounting altogether to 12 lb. This is stirred for $\frac{1}{2}$ hour daily for 14 days, then 3 lb. of finely-ground gum arabic are added, and the stirring is repeated for an additional 14 days, when the blacking will be ready for use.

(5) It has been proposed to treat the leaves and other portions of the mastic gum tree, *Pistacia lentiscus*, by decoction or distillation, principally to obtain from them a blacking which dries almost immediately after application, shines without the necessity of being brushed, and is much less liable to soil the clothes.

(6) Acmé blacking. To 1 gal. rectified spirit is added 21 dr. blue aniline, and 31 dr. Bismarck brown aniline, the solution of the two last being effected by agitation for 8–12 hours. After the solution is completed, the mass is allowed to settle, and the liquid portion is drawn off by spigots above the sediment, and filtered if necessary. The alcohol is placed in the apparatus first, then the colours, and the mixture agitated every hour for a space of 10–15 minutes. Of this liquid, $\frac{1}{4}$ gal. is added to 1 gal. rectified spirit, and in this are dissolved 11 oz. camphor, 16 oz. Venice turpentine, 36 oz. shellac. To 1 qt. benzine, add $3\frac{1}{2}$ fl. oz. castor oil, and $1\frac{3}{5}$ fl. oz. boiled linseed oil. The two solutions are then united by agitation, but should not be allowed to stand over 2 days in any vessel of

iron or zinc, as in the presence of the gums the colours will be decomposed by contact with zinc in 8 days, and with iron in 18–24 days.

(7) A quantity of ordinary starch is dissolved in hot water, and while still hot, oil or wax is added; the mixture is stirred and allowed to cool. When cold, a small quantity of iodine is added to give a bluish-black colour. To 1 gal. of this are added 8 oz. of a solution of iron perchloride or other per salt, a small quantity of gallic or tannic acid (or both), and sometimes about 2 dr. of oil of cloves with 8 oz. glycerine. The whole is thoroughly stirred.

(8) Nicolet, of Lyons, prepares boot blacking by dissolving 150 parts wax and 15 of tallow in a mixture of 200 of linseed oil, 20 of litharge, and 100 of molasses, at a temperature of 230° to 250° F. (110° to 120° C.). After this, 103 parts lampblack are added, and when cold it is diluted with 280 of spirits of turpentine, and finally is mixed with a solution of 5 of gum lac and 2 of aniline violet in 35 of alcohol.

(9) Hein, in Kaufering, makes another kind of shoe blacking by melting 90 parts beeswax or ceresine, 30 of spermaceti, and 350 of spirits of turpentine, with 20 of asphalt varnish, and adds 10 of borax, 20 of lampblack, 10 of Prussian blue, and 5 of nitro-benzol.

(10) Brunner uses 10 parts bone-black, 10 of glucose syrup, 5 of sulphuric acid, 20 of train oil, 4 of water, and 2 of soda carbonate. The bone-black and glucose are stirred with the acid in a porcelain vessel until the whole mass is homogeneous and has a shining black surface when at rest. The soda is dissolved in a little water, and boiled with the oil under constant stirring until it forms a thick liquid; then the other mixture is stirred into it. By varying the proportions of these two mixtures, the blacking is made thinner and softer, or harder and firmer. The substances sold as French polish are mostly composed of these ingredients. In this and all other kinds of shoe blacking made with bone-black and sulphuric acid, the precaution must be observed of stirring rapidly and evenly after the acid is added, otherwise lumps will be formed that are difficult to crush, and the blacking will have a granular condition that does not belong to it. Good shoe blacking must always remain soft, and show a smooth uniform surface when applied to the leather.

(11) A good liquid blacking may be prepared by mixing 3 lb. lampblack with 1 qt. stale beer, and ½ pint sweet oil, adding thereto 1 oz. treacle, ¼ oz. green copperas, and ¼ oz. logwood extract. This furnishes a blacking which polishes easily and well.

(12) Cheap and good shoe blacking:— To 1 lb. best ivory black add 1 lb. treacle, 8 tablespoonfuls sweet oil, dissolve 1 oz. gum arabic in 2 qt. vinegar, with ½ lb. vitriol.

(13) Guttapercha. — To 30 parts syrup, contained in a boiler, add 9 of lampblack and 1½ of finest bone-black, and mix the whole intimately together. Heat 1½ part guttapercha, cut into small pieces, in a kettle over a coal-fire, until it is nearly all melted, add to it gradually, under constant stirring, 2½ parts olive oil, and when the guttapercha is all dissolved, ½ part stearin. Pour the latter mixture, while still warm, very slowly and gradually into the first-mentioned mixture, and when the whole has been thoroughly incorporated, add a solution of 2 1/10 part gum senegal in 6 of water, likewise stirring. Finally, the product may be aromatised by the addition of 1 1/10 part rosemary or lavender oils. This blacking produces a fine gloss of a deep black. It is not injurious to leather.

(14) Take ivory- or bone-black, any quantity, and to every pound put 1½ oz. measure of sulphuric acid, and well triturate it. It will become damp, like snuff. Next add cod oil, 2 oz. to the lb. If liquid add treacle, 3 oz. to the lb., and small beer to mix, or stale beer if for paste, enough to make up into a paste. Foots sugar is preferable to treacle, and a better black is got by adding ¼ oz. to the lb. of Prussian blue. It is improved if laid up light for a day or two after the first manipula-

tion, and again after the second, as a decomposition takes place.

(15) A fine, brilliant, elastic dressing for leather can be made as follows:—To 3 lb. of boiling water add, with continual stirring, ½ lb. white wax, 1 oz. transparent glue, 2 oz. gum senegal, 1½ oz. white soap, and 2 oz. brown candy. Finally, add 2½ oz. alcohol, and, after the whole is cooled, 3 oz. fine Frankfort black. The dressing is thinly applied to the leather with a soft brush, and after it is dried it is rubbed with a piece of fine pumice and polished with a stiff brush.

(16) 7 lb. each ivory black and treacle, well mixed with 2 qt. boiling water; add 2 lb. 10 oz. vitriol, and the previously thin liquid will become quite thick. After the effervescence has ceased, add 1 pint of any common oil—fish oil is the best. If you want it liquid, add stale beer or vinegar.

(17) Useful blacking for leather may be made thus:—Dissolve 11 lb. of green vitriol and 5 lb. tartaric acid in 9 gal. water. After the settling, draw off the clear liquid; then boil 16 lb. logwood with about 18 gal. water and 11 gal. of the fluid. Let the boiled mixture stand for about 8 days, pour it off from the sediment, dissolve in it 2 lb. grape sugar, and mix this liquid with the green vitriol solution. The blacking so obtained may be made still brighter by mixing the logwood decoction with 4 lb. aniline black-blue before the addition of the vitriol. The application of the blacking is very simple. The leather is first well brushed with a solution of soda, or still better with a spirit of sal-ammoniac, in 25 times as much water, to get rid of the grease. The blacking is then applied with the proper brush for the purpose.

(18) Finishing Black.—Mix together ½ oz. each gelatine and indigo, 1 oz. logwood extract, 2 oz. crown soap, 8 oz. softened glue, and 1 qt. vinegar; heat the whole over a slow fire, and stir until thoroughly mixed. Apply with a soft brush, and polish with a woollen cloth.

(19) Mix a quantity of bone-black with equal parts of neats'-foot oil and brown sugar, in proportions to produce a thick paste; then with vinegar and sulphuric acid in proportions of 3 parts of the former to 1 of the latter.

(20) Melt 2 lb. wax, and add ¼ lb. washed and well-dried litharge by screening it through a fine sieve; then add 6 oz. ivory black, and stir until cool, but not cold; add enough turpentine to reduce it to a thin paste, after which add a little birch or other essential oil to prevent it from souring.

(21) A liquid black is made by mixing 3 oz. ivory black with 1 tablespoonful citric acid, 2 oz. brown sugar, and a small quantity of vinegar, afterward adding 1 oz. each sulphuric and muriatic acids; mix the whole together, and add a sufficient quantity of vinegar to make 1 pint in all.

(22) Vinegar, 2 pints; soft water, 1 pint; glue (fine), 4 oz.; logwood chips, 8 oz.; powdered indigo, 2 dr.; potash bichromate, 4 dr.; gum tragacanth, 4 dr.; glycerine, 4 oz. Boil, strain, and bottle.

(23) A German journal gives the following:—Mix 200 parts shellac with 1000 of spirit (95 per cent.) in a well-stoppered bottle. Keep in a warm place for 2–3 days, shaking frequently. Separately dissolve 25 parts Marseilles soap in 375 of warmed spirit (25 per cent.), and to the solution add 40 of glycerine. Shake well and mix with the shellac solution. To the mixture add 5 parts nigrosin dissolved in 125 of spirit. Well close the vessel and shake energetically, and then leave the mixture in a warm place for a fortnight.

(24) Ivory black, 6 lb.; treacle, 4 lb.; gum arabic (dissolved in hot water), 2 oz.; vinegar, 2 gal.; sulphuric acid, 2½ lb.; indiarubber dissolved in about 1 pint of oil, 2 oz. Mix well together. This blacking may be applied by means of a brush, or a small sponge attached to a piece of twisted wire.

(25) Boot Top Liquid.—Oxalic acid, 1 oz.; white vitriol, 1 oz.; water, 30 oz. Dissolve, and apply with a sponge to the leather, which should have been previously washed with water; then

wash the composition off with water, and dry. This liquid is poisonous.

(26) A waterproof blacking, which will give a fine polish without rubbing, and will not injure the leather:—18 parts beeswax, 6 spermaceti, 66 turpentine oil, 5 asphalt varnish, 1 powdered borax, 5 vine twig (Frankfort) black, 2 Prussian blue, 1 nitro-benzol. Melt the wax, add powdered borax, and stir till a kind of jelly has formed. In another pan melt the spermaceti, add the asphalt varnish, previously mixed with the turpentine oil, stir well, and add to the wax. Lastly add the colour previously rubbed smooth with a little of the mass. The nitro-benzol gives fragrance.

Paste blackings are also made in a variety of ways, of which the following are the chief:—

(1) Bryant and James's indiarubber blacking may be made in a solid form by reducing the proportion of vinegar from 20 gal. to 12. The compound then only requires stirring for about 6 or 7 days in order to prepare it for use, and it may be liquefied by subsequent addition of vinegar.

(2) Dr. Artus manufactures blacking from the following materials:—Lampblack, 3 or 4 lb.; animal charcoal, ½ lb.; are well mixed with glycerine and treacle, 5 lb. Meanwhile guttapercha, 2½ oz., is cautiously fused in an iron or copper saucepan, and to it is added olive oil, 10 oz., with continual stirring, and afterwards stearine, 1 oz. The warm mass is added to the former mixture, and then a solution of 5 oz. gum senegal, in 1½ lb. water, and 1 dr. each of rosemary and lavender oils may be added. For use it is diluted with 3–4 parts of water, and tends to keep the leather soft, and render it more durable.

(3) All ordinary paste blackings require to be mixed with some liquid before application, causing considerable waste. It is claimed for the subjoined method of preparation, that by its means the blacking is rendered of such a condition that when merely dipped in water or other solvents the required quantity can be rubbed on to the article to be blacked without the cake crumbling or breaking up. The ingredients of the blacking are those in ordinary use, but it is brought to the required consistence by combination with Russian tallow, in the proportion of 3 per cent., and casting the mass into the desired forms. These may be cylindrical, &c., and may be enclosed in covers of cardboard, tinfoil, &c., in which the blacking can slide, so that when one end is pushed out for use, the remainder acts as a handle. The exposed end, when damped by immersion or otherwise, can be rubbed on the article without crumbling. The ivory black (animal charcoal) which has been used in the preparation of white paraffin, according to Letchford and Nation's patent, may be conveniently used for making blacking.

(4) The addition of sulphuric acid to animal charcoal and sugar produces lime sulphate and a soluble acid lime phosphate, which make a tenacious paste. Thus: Animal charcoal, 8 parts; molasses, 4; hydrochloric acid, 1; sulphuric acid, 2. These are well mixed. A liquid blacking may be produced from this by the addition of the necessary proportion of water.

(5) Fullers' earth, 8 oz.; treacle, 3 lb.; animal charcoal, 2 lb.; butter scrapings, 4 oz.; rapeseed oil, 4 oz.; strong gum water, ½ pint; powdered Prussian blue, ½ oz.; commercial sulphuric acid, 8 oz. If the blacking is required in a liquid form, add ½ gal. vinegar.

(6) To 1 lb. animal charcoal add 4 oz. commercial sulphuric acid; work them well together, and when the acid has done its duty upon the charcoal add 4 oz. fish or colza oil; stir the mixture till the oil is thoroughly incorporated, then pour in gradually a strong solution of washing soda or other suitable antacid, and continue the stirring till ebullition ceases, or the acid is neutralised. Next add about 8 oz. treacle, and then pour in a solution of gelatine and glycerine, in quantity about 2 qt. if liquid blacking is required, but less

will suffice to produce paste. The solution of glycerine and gelatine is made by dissolving the best size in hot water, in the proportion of 4 parts water to 1 of size, and then adding to every qt. of the liquid 1½ oz. glycerine. The addition of the glycerine and gelatine preparation gives great brilliancy, depth of colour, and permanency to the blacking when applied to leather, and at the same time makes it damp-proof; besides which the antacid has the effect of neutralising the sulphuric acid employed, and thus prevents the injurious action of that acid on the leather, as in the case of most ordinary blackings.

(7) Soften 1 part white glue in water, add 3 parts crown soap, and heat the whole over a slow fire until the glue is thoroughly dissolved; moisten 3 parts bone-black with vinegar, and mix it with 1 part wheat starch, beaten smooth in cold water; mix the whole, and allow it to stand over a slow fire for ½ hour, stirring it all the time; then turn it into another kettle and stir it until it is cold. To use, dissolve a small quantity in sour beer or vinegar, and apply with a brush, spreading it as thinly as possible.

(8) A leather varnish or polish is prepared by Gunther, of Berlin, by mixing a filtered solution of 80 parts shellac in 15 of alcohol, with 3 of wax, 2 of castor oil, and a sufficient quantity of pigment. The mixture is evaporated *in vacuo* to a syrup. The varnish is applied to the leather with a brush moistened with alcohol or with a colourless alcoholic varnish.

(9) Soften 2 lb. good glue, and melt it in an ordinary glue kettle; then dissolve 2 lb. Castile soap in warm water and pour it into the glue; stir until well mixed, and add ½ lb. yellow wax cut into small pieces; stir well until the wax is melted, then add ½ pint neats'-foot oil and enough lampblack to give the desired colour. When thoroughly mixed, it is ready for use.

(10) Waterproof. — Melt together 4 oz. black rosin and 6 oz. beeswax over a slow fire; when thoroughly dissolved, add 1 oz. lampblack and ¼ lb. finely powdered Prussian blue; stir the mixture well, and add sufficient turpentine to make a thin paste. Apply with a cloth and polish with a brush.

(11) Liebig's. — Mix bone-black in ½ its weight of molasses, and ⅛ its weight of olive oil, to which add ½ its weight of hydrochloric acid and ¼ its weight of strong sulphuric acid, with a sufficient quantity of water to produce a thin paste.

(12) Molasses, 1 lb.; ivory black, 1¼ lb.; sweet oil, 2 lb. Rub together in a Wedgwood mortar till all the ingredients form a perfectly smooth homogeneous mixture; then add a little lemon juice or strong vinegar — say the juice of one lemon, or about a wineglassful of strong vinegar — and thoroughly incorporate, with just enough water added slowly to gain the required consistency.

(13) Ivory black, 2 lb.; molasses, 1 lb.; olive oil, ¼ lb.; oil of vitriol, ¼ lb. Add water to gain required consistency.

(14) Take 1 part ivory black, ⅛ of melted tallow, and work up well in a mortar. Incorporate with this paste ½ part treacle, ¼ of sulphuric acid, and ⅛ of spirits of salt. This will form an excellent paste blacking.

For application to *dress* boots the following compositions are prepared:— (1) Gum arabic, 8 oz.; molasses, 2 oz.; ink, ½ pt.; vinegar, 2 oz.; spirit of wine, 2 oz. Dissolve the gum and molasses in the ink and vinegar, strain, and then add the spirit of wine.

(2) Mix together the whites of 2 eggs, 1 teaspoonful spirits of wine, 1 oz. sugar, and as much finely pulverised ivory black as may be required to produce the necessary shade of black. Apply with a sponge, and polish with a piece of silk.

(3) Mix together ½ lb. each ivory black, purified lampblack, and pulverised indigo, 3 oz. dissolved gum arabic, 4 oz. brown sugar, and ¼ oz. glue dissolved in 1 pint water; heat the whole to a boil over a slow fire, then remove, stir until cold, and roll into balls.

Harness blacking is not made in the same way as boot blacking. The following are some of the methods of preparing the former kind:—

(1) Glue or gelatine, 4 oz.; gum arabic, 3 oz.; water, ¾ pint. Dissolve by heat, and add of treacle, 7 oz.; finely powdered animal charcoal, 5 oz.; and then gently evaporate until the compound is of the proper consistence when cold, stirring all the time. It must be kept corked.

(2) Mutton suet, 2 oz.; beeswax, 6 oz.; melt them, and add sugar candy, 6 oz.; soft soap, 2 oz.; lampblack, 2½ oz.; finely powdered indigo, ½ oz. When thoroughly intermixed, add oil of turpentine, ¼ pint.

(3) Beeswax, 1 lb.; animal charcoal, ¼ lb.; Prussian blue, 1 oz.; ground in linseed oil, 2 oz.; oil of turpentine, 3 oz.; copal varnish, 1 oz. Mix them well, and form the mass into cakes while it is still warm.

(4) Add to No. 3, while still warm, soft soap, 4 oz.; oil of turpentine, 6 oz.; put into pots or tins while warm.

(5) Isinglass, ¼ oz.; finely powdered indigo, ¼ oz.; soft soap, 4 oz.; glue, 5 oz.; logwood, 4 oz.; vinegar, 2 pints; ground animal charcoal, ½ oz.; beeswax, 1 oz. Infuse the logwood in the vinegar for some time with gentle heat, and when the colour is thoroughly extracted strain it, and add the other ingredients. Boil till the glue is dissolved, then store in stoneware or glass jars. Said to be very useful for army harness.

(6) Melt 4 oz. mutton suet with 12 oz. beeswax, 12 oz. sugar candy, 4 oz. soft soap dissolved in water, and 2 oz. finely powdered indigo. When melted and well mixed, add ½ pint turpentine. Lay it on with a sponge, and polish with a brush. A good blacking for working harness, which should be cleaned and polished with it at least once a week.

(7) 3 sticks black sealing-wax dissolved in ½ pint alcohol, and applied with a sponge; or lac dissolved in alcohol, and coloured with lampblack, answers the same purpose. This is intended for carriage harness; it is quick drying, and hard and liable to crack the leather, so should be applied as seldom as possible.

(8) A good blacking consists of:—Hogs' lard, 4 oz.; neats'-foot oil, 16 oz.; yellow wax, 4 oz.; animal charcoal, 20 oz.; brown sugar, 16 oz.; water, 16 oz. Heat the whole to boiling, then stir it until it becomes cool enough for handling, and roll it into balls about 2 in. in diameter.

(9) Soften 2 lb. glue in 1 pint water; dissolve 2 lb. soap (Castile is the best, but dearest) in 1 pint warm water; after the glue has become thoroughly soaked, cook it in a glue-pot, and then turn it into a larger pot; place this over a strong fire, and pour in the soap water, slowly stirring till all is well mixed; then add ½ lb. yellow wax cut into slices; let the mass boil till the wax melts, then add ½ pint neats'-foot oil and sufficient lampblack to impart a colour; let it boil a few minutes and it will be fit for use.

(10) When harness has become soiled it can be restored by the use of the following French blacking:—Stearine, 4½ lb.; turpentine, 6¾ lb.; animal charcoal, 3 oz. The stearine is first beaten into thin sheets with a mallet, then mixed with the turpentine, and heated in a water bath, during which time it must be stirred continually. The colouring matter is added when the mass has become thoroughly heated. It is thrown into another pot, and stirred until cool and thick; if not stirred, it will crystallise, and the parts will separate. When used, it will require warming; it should be rubbed on the leather with a cloth, using very little at a time, and making a very thin coat. When partially dry, it is rubbed with a silk cloth, and will then give a polish equal to that of newly varnished leather, without injuring it in any way.

(11) 2 oz. shellac, 3 pints alcohol, 14½ pints fish oil, 19 pints West Virginia oil, 1 lb. lampblack, 1 pint spirits of turpentine, 9 pints coal oil; the two first are combined, then the third is added, and all the others are well mixed.

(12) Heat together over a slow fire, 2 oz. white wax and 3 oz. turpentine; when the wax is dissolved, add 1 oz. ivory black and 1 dr. indigo, thoroughly pulverised and mixed; stir the mixture until cold. Apply with a cloth, and polish with a shoe-brush.

(13) An excellent oil for farm and team harness is made of beef tallow and neats'-foot oil as follows:—Melt 3 lb. pure tallow, but do not heat it up to a boil; then pour in gradually 1 lb. neats'-foot oil, and stir until the mass is cold; if properly stirred, the two articles will become thoroughly amalgamated, and the grease will be smooth and soft; if not well stirred, the tallow will granulate and show fine white specks when cold. The addition of a little bone-black will improve this oil for general use.

(14) Melt together 8 oz. beef suet, 2 oz. neats'-foot oil, 2 oz. white wax, and 2 oz. pulverised gum arabic; add 1 gill of turpentine, and sufficient bone-black to give the whole a good colour; stir until thoroughly mixed, remove from the fire, continue to stir until cold, then roll into balls. To apply, warm the ball, rub it on the leather, and polish with a woollen cloth.

(15) English ball blacking for harness is composed of 1 oz. lard, 1 oz. beeswax, 8 oz. ivory black, 8 oz. sugar, 4 oz. linseed oil, and 2 or 3 oz. water.

(16) Another kind is made of 2 oz. hogs' lard, 8 oz. best neats'-foot oil, 2 oz. beeswax, 10 oz. ivory black, and 8 oz. water. Heat the whole to a boil, remove from the fire, stir until sufficiently cool, and form into balls about 2 in. in diameter.

(17) A third description is made of 2 oz. each ivory black, copperas, and neats'-foot oil, 4 oz. brown sugar, 4 oz. soft water, and 1 oz. gum tragacanth; boil until the water has evaporated, stir until cold, then roll into balls or mould into cakes.

(18) A fourth is made of ½ lb. beeswax, 4 oz. ivory black, 2 oz. Prussian blue, 2 oz. spirits of turpentine, and 1 oz. copal varnish; melt the wax, stir in the other ingredients, and, when cool, roll into balls.

(19) Still another famous harness and saddlery blacking is made of ¼ oz. isinglass, ¼ oz. indigo, 4 oz. logwood, 2 oz. soft soap, 4 oz. glue, and 1 pint vinegar; the whole is warmed, mixed, strained, allowed to cool, and is then ready for use.

(20) Mix 1 oz. indigo, 1 lb. extract of logwood, 1 oz. softened glue, and 8 oz. crown soap (common soft soap can be used if the other cannot be had) in 2 qt. vinegar; place the mass over a slow fire, and stir until thoroughly mixed. Apply with a soft brush, and use a harder one for polishing.

(21) Restoring Leather-covered Mountings.—Melt 3 parts white wax, then add 1 of gum copal, dissolved in linseed oil, and 1 of ivory black; allow the mass to boil for 5 minutes, remove it from the fire, stir until cold, and roll up into balls.

(22) For the flesh side mix together 1 lb. prime lampblack and 12 lb. pure neats'-foot oil; melt 6 lb. good tallow, and add it while hot to the lampblack and oil. Mix well, and when cold it will be fit for use.

(23) Another: to 1½ lb. lampblack add 1 gal. pure neats'-foot oil, and 1 qt. vinegar black; allow it to stand 24 hours, and it will be ready for use.

(24) Crown Soap Black.—Dissolve, over a slow fire, 1 lb. beeswax, 1 lb. crown soap, 3 oz. indigo, 4 oz. ivory black, and ½ pint oil of turpentine; as soon as dissolved, remove from the fire, and stir until cold.

(25) Take 6 oz. turpentine, 3 oz. beeswax, 1½ oz. ivory black, ½ oz. indigo blue, ½ oz. ink. Cut the beeswax fine, pour the turpentine on it, let it stand covered 5 or 6 hours, and mix well together; to be kept covered.

(26) Digest 12 parts shellac, 5 white turpentine, 2 gum sandarach, 1 lampblack, with 4 of spirits of turpentine, and 96 of alcohol.

(27) For Russet Leather.—Mix together 1 part palm oil and 3 parts common soap, and heat up to 100° F.; then add 4 parts oleic acid, and 1¾ of tanning solution, containing at least $\frac{1}{10}$ of tannic acid (all parts by weight), and stir

until cold. This is recommended as a valuable grease for russet leather, and as a preventive of gumming.

(28) Cordova Wax. — Mix together 1½ pint red acid (chromic), 1 pint beer, 1 gill thick glue, 2 oz. ivory black, and 1 dr. indigo; boil for ½ hour and apply with a sponge.

(29) Wax Polish. — Melt together 1 lb. white wax, 1 lb. crown soap, 5 oz. ivory black, 1 oz. indigo, and ½ pint nut oil; dissolve over a slow fire, stir until cool, and turn into small moulds.

(30) French Polish.—½ lb. logwood chips, ¼ lb. glue, ¼ oz. indigo, ¼ oz. soft soap, ¼ oz. isinglass; boil in 2 pints vinegar and 1 pint water for ¼ hour; strain, and bottle for use. The leather must be freed from dirt, and the polish applied with a piece of sponge.

Liquid blacking is usually filled into small bottles of very coarse stoneware, closed by corks. Paste blacking is formed into cakes, which are secured in waterproofed paper, generally prepared by steeping the paper first in boiled linseed oil, pressing, then hanging up to dry for 18 hours to a week. The following is an improved way of making a waterproof paper of superior quality, thinner, but equally strong, and capable of drying in less than a minute. The paper is steeped in a melted or fluid composition, consisting of paraffin, wax, or hard tallow, in combination with crude or other turpentine, in the proportions of two to one. It is then immediately pressed, and the surplus composition is removed by passing it between rollers heated by steam. By using paper in endless sheets, the whole process might be made continuous, the paper being finished for use or storing by the time it leaves the rollers.

It is obvious that the manufacture of blacking requires neither skill nor capital. It may be conducted on almost any scale according to the demand.

COOLING.—The artificial production of a low temperature is becoming a matter of great importance in connection with many of our leading industries, besides being a necessary element under some conditions of sanitation. As processes are simplified and cost is reduced, it will come to be generally applied in numerous directions which are now closed to it. Though apparently a very simple matter, the subject will bear dividing into several sections for convenience of discussion.

Cooling Air.—Means of cooling the air in factories, public buildings, and private dwellings have long been a subject of study and experiment. The methods proposed may be classed under two heads: (1) fresh air is introduced into a given space, or (2) the conduits by which the air is to pass are kept at a low temperature. Under the first head come the 4 systems proposed by Péclet: (*a*) mechanical action is employed, and the new air is compressed, and expands at the moment of escape; (*b*) evaporation is used by passing the air over moist surfaces; (*c*) it is refrigerated by circulation through pipes artificially cooled by ice, &c.; (*d*) it is passed through subterranean channels whose temperature, nearly always invariable, is actually equal to the mean temperature at the surface. The 4 systems may be described in detail.

(*a*) *By Mechanical Action.* — Much was anticipated from the ingenious principle illustrated in lectures of natural science by the ordinary air match (*briquet*). It is known that when a gas is condensed, it becomes heated; on the other hand, when it is expanded, it cools. Suppose a certain amount of air has been condensed in a receiver, and that after having left the apparatus alone for some time, the temperature of its capacity, and the gas contained within it, should be equalised with that of the surrounding air; if the air be liberated from the receiver, it will be placed in the same condition as a gas expanding to resume its normal state of atmospheric pressure, and it would follow that it would become cooler in proportion to its degree of condensation. This experiment has led several inventors to applications for the production of cool air.

In order to render this means efficacious, it is necessary that the sensible heat developed in the compression should be

destroyed by the refrigeration of the receiver containing the compressed air, otherwise the new air would be introduced at an equal temperature to that of the exterior atmosphere. Suppose this condition to be fulfilled. Let t' be the temperature of the compressed air, which will thus be that of the external temperature; P', its pressure; t and P, the temperature and pressure of the expanded air when it reaches the interior; γ, the relation of the capacity of the air at pressure and mean volume; we have, according to a formula of Poisson,

$$\frac{1+\alpha t'}{1+\alpha t} = \left(\frac{P'}{P}\right)\frac{\gamma-1}{\gamma};$$

the quantity P is evidently equal to the atmospheric pressure; taking it as unity, and observing that t and t' never have anything except feeble values, this equation may be put into the following form:—

$$P' = \left\{1+\alpha\,(t'-t)\right\}\frac{\gamma-1}{\gamma},$$

and replacing α and γ by their values:—

$$P = \left\{1 + 0{\cdot}00867\,(t'-t)\right\}\ 3{\cdot}375,$$

for a lowering of temperature by 5°, $t'-t=5$, we deduct

$$P' = 1{\cdot}06.$$

This compression of atmosphere $\frac{6}{100}$, or, in mercury, of 46 mm., at first sight appears small. At the hospital Lariboisière, in a space containing 306 beds, the new air immediately after the action of the ventilator was compressed to 28 mm. of water, or about 2 mm. of mercury. Now this compression, although it is excessively slight, requires, from the great quantity of air to be compressed, a 12-horse steam-engine. If the same quantity of air had to be compressed by 46 mm. (mercury), it would require for an apparatus more useful than that of the Lariboisière Hospital a steam-engine 15 to 18 times as powerful, or of 180 to 240 horse-power. A power of $\frac{3}{5}$ to $\frac{4}{5}$ of a horse-power would thus be required for each invalid. Without occupying oneself with other difficulties presented by this method, it may be seen, from this consideration alone, that it is impracticable.

In a mine in South Wales, an apparatus suggested by Piazzi Smith, despite the imperfection of the system, has met with some success. This apparatus is thus composed:—(1) of a pump for the compression of the air; (2) of a refrigerator, composed of a long tube or series of tubes, within which circulates a current of water, while the compressed air passes round, the disengaged heat of which is thus absorbed; (3) of a detention cylinder, where the air expands and cools to a temperature nearly proportionate to its primitive temperature: this cylinder was utilised to work the pump. The process is not only impracticable in consequence of the considerable mechanical labour required, the refrigeration produced by expansion not being nearly as high as that indicated by the calculation, in consequence of the heat developed in the air by the jets of compressed gas and the heat furnished by the casing.

The principle of this mode of refrigeration has been elegantly carried out by a beautiful experiment of Thilorier. It has been not less happily applied to the fabrication of ice on a large scale, which proves, as a general result, that the process is capable of inducing intense cold. Gorrie's machine has received much notice in America; Windhausen's machine in Germany; in England, the machines of Harrison and of Siebe; in France, the processes of Carré and of Tellier are still more remarkable, and their reputation has long since been established.

(*b*) *By Evaporation.*—By this means fresh air is easily cooled, and almost without expense; but its composition is altered by the introduction of a further degree of humidity, which is a fatal inconvenience in many cases.

One *gramme* of water in evaporation absorbs or renders latent a quantity of heat enough to cool 1 cub. *mètre* of air by 2° C. Let p be the weight in *grammes* of the vapour of water contained in 1 cub. *mètre* of external air,

let π represent the weight of the water introduced by evaporation; by p_1, the weight of 1 cub. *mètre* of internal air, and by y the resultant lower temperature, we obtain—

$$p + \pi = p_1,$$
$$y = 2\pi,$$

and

$$p + \frac{y}{2} = p_1.$$

The evaporation and lowering of the temperature at an end, the air is saturated. The value of p and the exterior temperature t being known, this limit may be determined by tables giving the weight of the saturated vapours at different temperatures.

To understand this method of refrigeration, the limit has been calculated at different values of p, in cases where the temperature would be 30° C.; at the same time, the influence of vaporised water on the breathing has been ascertained; and finally the relative humidity of the internal air, on which the cutaneous transpiration depends, has been determined by supposing that the temperature of the fresh air, on its introduction to the lungs, was raised some 5° C.

The results arrived at are thus tabulated :—

Weight of the Vapour of Water per cubic mètre of Air.			Lowering of Temperature.	Temperature of the Air.		Relative Humidity of the Air.		Pulmonary Temperature.			
Exterior, p.	Introduced by evaporation, ω.	Internal, p_1.		Newly cooled, $t - y$.	Interior, $t - y + 5°$.	Exterior.	Interior.	Exterior Air.	Interior Air.	Difference.	Relation (11) & (9)
(1) grm.	(2) grm.	(3) grm.	(4) deg.	(5) deg.	(6) deg.	(7)	(8)	(9) grm.	(10) grm.	(11) grm.	(12) grm.
0	9·62	9·62	19·25	10·75	15·75	0·00	0·72	17·05	11·47	5·58	0·33
2	8·75	10·75	17·50	12·50	17·50	0·06	0·72	15·90	10·82	5·08	0·32
4	7·95	11·95	15·90	14·10	19·10	0·13	0·725	14·75	10·11	4·64	0·31
6	7·20	13·20	14·40	15·60	20·60	0·19	0·73	13·59	9·36	4·23	0·31
8	6·50	14·50	13·00	17·00	22·00	0·25	0·74	12·42	8·60	3·82	0·31
10	5·80	15·80	11·60	18·40	23·40	0·32	0·74	11·25	7·82	3·43	0·30
12	5·12	17·12	10·25	19·75	24·75	0·38	0·74	10·08	7·03	3·05	0·30
14	4·50	18·50	9·00	21·00	26·00	0·44	0·74	8·89	6·20	2·69	0·30
16	3·90	19·90	7·80	22·20	27·20	0·51	0·74	7·70	5·36	2·34	0·30
18	3·33	21·33	5·66	23·34	28·34	0·57	0·74	6·50	4·50	2·00	0·31
20	2·80	22·80	5·60	24·40	29·40	0·63	0·75	5·30	3·60	1·70	0·32

The examination of this table leads to the following consequences, which are at once evident :—1. The temperature decreases in proportion to the augmentation of humidity in the exterior atmosphere. 2. The relative humidity of the interior air is almost constant and equal at 0·74, which corresponds to 87° of the hair hygrometer, according to the tables of Gay Lussac, and to 82 according to those of August. The temperature of the fresh air does not rise in the interior in a mean quantity of 5° as supposed; it will be greater during greater refrigeration; but during slighter refrigeration, the relative humidity of the interior air, instead of being constant, then augments with the

quantity of humidity contained in the exterior atmosphere. In summer, the humidity of the external air being always sufficiently great, the supposition which had been adopted tends rather to reduce the relative humidity of the interior air than to augment it. Lastly, an account has been taken of the individuals within the area who, by double perspiration, introduce new volumes of watery vapour into the surrounding air. But it also leads to the unexpected result that the humidity introduced by the evaporation reduces pulmonary transpiration for an equal temperature of external air, no matter what its humidity, in an important proportion, sensibly constant, which, when that temperature is 30°, would be from 30 to 31 per cent., or nearly one-third. The action of interior air upon the animal economy is, in consequence of these diverse circumstances, different from that of external air.

The waste of heat increases by direct refrigeration, by contact and radiation; on the other hand, it diminishes by double perspiration. Are these variations in an inverse sense of the principal elements of this waste, taken together, advantageous? Will the calorific equilibrium be more easy? and would it more closely approach the physical equilibrium? Let us take one of the cases in the table—that, for instance, where the moisture contained in the exterior air is 10 *grm.* per cub. *mètre*. The temperature of the interior air will be lowered to 23·4° C., and thus will be 6 6° C. less than that of the external air. The direct refrigeration of 2·5 cals. per degree is composed of two terms almost equal in intensity, contact, and radiation; the first depends upon the temperature of the interior air, but the second specially upon that of the walls of the area, which is more elevated. Taking for the latter a mean between the temperature of the exterior and interior airs, the direct refrigeration will be greater in the interior than in the exterior by 12·5 cals. per hour. Pulmonary transpiration being weaker by 3·43, the waste in this case would be diminished by 2 calories, and there would remain 10·5 cals., from which there is again to be deducted the heat corresponding to the reduction found in cutaneous transpiration. A reduction of 18 *grm.* an hour would compensate for these 10·5 cals., and thus, in respect of waste, the same conditions would exist as in the exterior atmosphere. Can it attain this figure? No exact experiments on the point exist.

It should be considerable, as all at once the temperature diminishes 6·6°, and the relative moisture rises from 0·32 to 0·74; in degrees of the hair hygrometer from 55° to 87°. The air, which is very dry, causing an abundant perspiration, becomes very moist, which only admits of very weak perspiration.

Skin perspiration depends much upon the quantity of watery vapour which the surrounding air can yet contain before arriving at a point of saturation. If it were proportionate to that quantity, it would vary, in the two cases, as 21·4 to 5·5; it would then be 4 times weaker in the interior air than in the exterior air. On the other hand, it is known that this perspiration very widely varies; different experimentalists have found the mean expressed in numbers from 30 *grm.* to 100 *grm.* an hour, according to circumstances. It is also known that in air at 15° C., half-saturated, and therefore capable of containing 6·3 *grm.* of watery vapour per cub. *mètre* more, the mean is 35 *grm.* per hour.

From these various considerations, it may be concluded that for a like play of the organs, the reduction of skin perspiration in the interior would at most be 18 *grm.* The calorific equilibrium (standard of heat) would require an additional effort from them to be established; the equally considerable reduction of pulmonary perspiration would be a further cause of trouble and discomfort. In short, the interior air, despite its being cooler, would be far more unfavourable than the exterior. The exterior air, just now taken at 23·4° C., to rise at 30° C., would re-

quire per cubic *mètre* a volume of heat represented by $1{\cdot}22 \times 0{\cdot}24 \times 6{\cdot}6 = 1{\cdot}93$ cal. The 3·43 *grm.* of watery vapour to be added to the exterior air at 23·4° C., to form the interior air would give in a latent condition a volume of heat equal to two calories. The interior air also contains, although at a much lower temperature, a much more considerable volume of heat than the exterior air, which leads to the conclusion that the action of the surrounding atmosphere on the calorific equilibrium depends less upon its temperature than upon the quantity of heat contained in it. In summer the heat is far more insupportable and overwhelming when the air is very moist than in higher temperatures when it is dry. Such a result obtained in a particular case, is evidently capable of general application.

Cooling by steam vapour therefore acts inefficaciously upon the organism; it simply cools the area in which it acts, without refreshing the individuals contained in that area.

It will hereafter be seen, in the description of the kind of apparatus which have been tried, that the system employed at the Institute has proved the truth of this view. This system cools the fresh air by evaporation, but also by water drawn from a well at 12° C.; the lowering of the temperature of the interior atmosphere varies from 4° to 6° C. Although the conditions of this refrigeration are more favourable than if obtained by evaporation alone, experience has shown that it produces no benefit, and even rather occasions a certain amount of discomfort.

A great number of contrivances have been put up upon this principle, but in general the experimentalists have neglected to take note of the tests to which they have been put; these would have most certainly been valuable to them. Therefore the proposed engines, with the exception of some few, are defective; and even those which have received more general approval do not comply with the economical conditions forming in this case, as in others, one of the best guarantees of success. D'Arcet has shown that to be in a proper healthy state every cub. *mètre* of air should not contain more than 7 *grm.* of water, agreeing in this with the physicians.

It would be running into another extreme to dry the air beyond a certain point. It is necessary that there should be a certain quantity of water in the air, but not too much. In the course of his interesting researches into ventilation, General Morin was struck with the stress laid by the English experts, who have greatly occupied themselves with the question, upon the advantages in point of health, upon arrangements giving the heated or unheated air introduced into inhabited places a great amount of hygroscopicity. Thus, in summer the following plan is often adopted in London, well deserving attention. Immediately beneath the hall to be ventilated is another chamber, into which the outer air penetrates by several large bays; before this falls a canvas curtain to arrest the sooty particles which are floating about in the atmosphere. In front of the curtain, a tap is fitted to a tube pierced with a number of capillary holes, regulating the fall of a regular water spray or dust mixing with the atmosphere imperceptibly, so that it falls to the ground without wetting it to any extent. This arrangement is intended to augment the hygroscopicity of the atmosphere, and should have upon it an influence similar to that produced by steam. The English engineers who have adopted this method explain its advantage in an original way. According to them, the vaporisation of the water-spray thus traversed by the affluent air is accompanied, like the dew, the rain storms, and in accordance with the experiments of De Saussure and De Pouillet, by the development of a certain amount of electricity, which modifies the air in a salutary way by producing ozone in it. Thus, there would be a method of purifying the air, both simple and efficacious, especially in the summer. It is at present beyond doubt that the dispersion and dissolution in the air of a certain quantity of

water in the form of spray, as it is used in some bath establishments, sensibly modifies the electric condition of the air; this element containing active oxygen, has in it a high degree of the property of destroying, by combustion, certain miasmata, certain bodies in a state of putrefaction. In consequence it is only necessary to prove the existence of this beneficent gas in the atmosphere which permeates the kind of fog formed by water in the form of dust, to conclude that the evaporisation of this water, beside the accretion of hygroscopicity and the lowering of the temperature produced by it, should have an influence upon the animal economy and the cleansing of human habitations, deserving of the attention of inventors.

If such be the case, there ought to be, in proper arrangements of contrivances founded upon this principle, some solution of the problem of air cooling. To this we are further led by the observation of very palpable facts. In proportion as greater heights are attained in the atmosphere, so the presence of ozone is recognised; therefore there is no other reason to be assigned for its absence in the atmosphere, even at a very small degree of elevation, than the presence of these noxious matters so abundantly disengaged at the surface of the soil. The part which ozone has to play in the great circle of the phenomena of nature is no doubt in those superior regions to cleanse and purify the atmospheric air from the deleterious compounds produced by the decomposition going on at the surface in vegetation and life, introducing themselves in a continuous manner into it, and to restore them to the condition of the fixed elements—nitrogen, oxygen, carbonic acid, and water. Ozono-metrical observations which have been made at different times and places, have constantly established a coincidence between the ozonisation of the atmosphere and various epidemics. This ozonisation is considerable during epidemics affecting the throat and chest, when affections of the lungs are common; and the contrary may take place, it may even arrive at a zero point during cholera, malaria, and the prevalence of paludine fevers.

Much was expected of the apparatus designed by Duvoir for the ventilation of the halls of the Institute. Despite all his experience, the intelligent constructor took a wrong course; but it must be admitted that his apparatus was not without merit. A wind shaft was placed on the roof above the hall, the conduct house containing a vertical cylinder, 13 ft. high, full of water, similar to heating pipes; 104 equally vertical tubes were enclosed in this kind of casing of a diameter of 1½ in., and a stream of water was kept continually flowing through these tubes. The fresh air passing by these tubes became moist and cooled. The windows being closed, the movement became evident by the chimney draught; it continued strongly even when doors and windows were opened. The fresh air was sucked down rapidly through the wind shaft, and the apparatus began to work independently of the chimney. The action was, therefore, similar to that of a chimney draught; the air being cooled instead of heated, the draught being downward instead of upwards. Having acquired a certain degree of rapidity owing to the pressure consequent upon its refrigeration, the fresh air reached the rooms in horizontal layers; heated by the persons assembled, it rose and escaped by open windows placed at a uniform height. Duvoir's apparatus thus acted well, but did not fulfil all the required conditions, owing to the causes already mentioned. Péclet subsequently improved upon this system by causing the air to be cooled to pass into an apparatus formed of a number of little moistened tubes not in the interior, as with Duvoir's plan, but at the exterior. Each tube was surrounded by a sheet kept constantly wet, and the evaporation was stimulated by the action of a strong ventilator. Still the necessary amount of moisture was not introduced.

Among apparatus of this kind, Baumbauer's plan is particularly to be noticed. Its simplicity attracted much attention.

It was composed of a cylinder traversed by a minutely divided current of water, a current of air proceeding in the same direction, and then flowing into a chimney draught in which a gas-jet was burning; this cylinder was enclosed by another open at both ends, containing transverse metallic gauze, by which the cold was to pass to the air descending between the cylinders by the effect of the lower temperature.

(*c*) *By Ice.*—Ice as a refrigerant may be placed either within or without the shafts bringing in fresh air. In the first case, generally preferred by the inventors, it melts, and afterwards evaporates in the fresh air. The cold resulting from the fusion and warming of the water produced not being more than $\frac{1}{6}$ of that due to evaporation, it follows that the amount of moisture introduced into the air is about $\frac{1}{7}$, or nearly as much as that of evaporation alone. The refrigeration obtained has the same inconveniences as before, and is equally ineffectual. When the ice surrounds the pipe without being in contact with the fresh air, it gives, by fusion and the heating of the water thus produced, about 100 calories of cold per *kilo.* (2·2 lb.). In a hospital, for instance, a specific ventilation of 100 cub. *mètres* with a temperature of 5° C., would require per bed and hour $100 \times 0{\cdot}24 \times 5 = 120$ calories of cold, to be raised by reason of loss to 200 calories, or 2 *kilo.* (4·4 lb.) of ice. In warm countries, this refrigeration would be wanted, generally speaking, at least for 5 hours a day during 100 days; therefore it would need, per bed per year, the employment of about 1 ton of ice. In temperate climates it would always be possible to obtain that quantity of ice, despite its importance; it would always cause a high amount of expense in consequence of the ice-houses to be constructed, and even the harvesting of the ice during winter. But in hot climates, precisely when the consumption would be the greatest, it would be almost impossible to obtain it without enormous expense. In point of fact, this method of refrigeration must be considered impracticable when ice is not very cheap, and cold cannot be produced as inexpensively as heat.

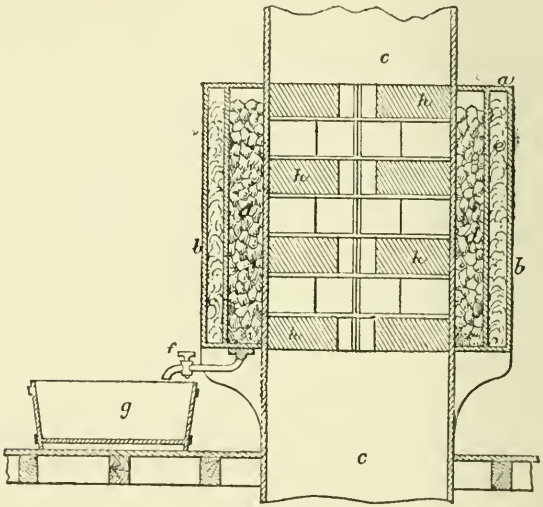
The apparatus shown in Fig. 12 and based upon this principle, may be used in some cases; its simplicity has gained it a certain degree of support. The air conduit *c* passes through a casing *a b*, formed of a double lining. The interior space *d* surrounding the air conduit contains ice. The next space *e* is filled with tan, or, still better, down or wool, which acts as a non-conductor of cold. A tap *f* lets off the water formed by the melting of the ice into a receiver *g*. The air conduit *c* is fitted with mechanical fly-wings *h*, which increase the contact of the air with the sides cooled by the ice. These metallic fly-wings are fixed to a vertical axis, and in successive rows, but in different planes, which multiplies the surface over which the air has to pass. A mixture of ice and salt is better than pure ice, should ice be dear, or the casing *a b* be small in comparison with the degree of refrigeration required. This contrivance, which manifests ingenious details of construction, may have been applied with success, but it is far from being sufficiently cheap. It has been calculated that the cost of cooling the wards of the Lariboisière Hospital in summer by this apparatus would equal the cost of warming them in winter, taking the minimum price of $\frac{1}{4}d.$ per lb. of ice.

Refrigerating mixtures in point of economy, so far as they have been realised, have turned out altogether illusory. True a considerable degree of cold has been attained, but the expense is too high. An apparatus of this kind would only be accessible to amateurs who could afford to pay a fancy price, but may be adopted in some particular instances. If it were possible to obtain inexpensive chemical mixtures for producing great degrees of cold, this model might be advantageously employed.

(*d*) *By Underground Channels.*—The temperature of the soil to a depth of 6, 10, or 20 yd., according to its nature and the local position, is on an annual average nearly the same as the tempera-

ture of the air at the surface, but the variations to which it is subject are much less, and decrease rapidly with the depth; at 3 or 4 yd. these variations are not more than 2° or 3° C., and the temperature may practically be regarded as constant. By causing currents of air to pass through vaults built at that depth, they will be perceptibly cooled in summer if they are of any length. As such conduits are almost necessarily a part of any ventilation by injection, the cooling of air is effected by this system without any additional expense—that is to say, naturally. In two experiments made at the Necker Hospital the following results were obtained:—

FIG. 12.



Average Temperature of the Hall.	Temperature of the Fresh Air at its introduction.				Exterior Temperature in the Shade.	Difference, or average Refrigeration obtained.
	1	2	3	Average.		
22·3°	22·2°	20·6°	18·8°	20·5°	25·1°	4·6°
22·4	22·6	21·2	19·6	21·1	26·0	4·9

The subterraneous channel is an aqueduct of masonry, built under the cellars at a depth of about 4 yd.; the distances traversed in this conduit are on the average 15 yd. for the first inlet orifice, 35 yd. for the second, and 55 yd. for the third. On the first 15 yd. of the conduit the cooling is 2·9° C. in the first experiment, 3·4° C. in the second experiment; that is to say, 3·1°

C. on the average. On the 40 yd. following the cooling is from 3·4° C. in the first experiment, and from 3° C. in the second; it is therefore evidently the same. In consequence of the total refrigeration which increases from the first inlet to the last, the fresh cooled air is introduced into the same hall at different temperatures, an inconvenience in itself sufficiently important; to this may be added some other disadvantages.

As the quantity of air which passes through the first portion of the aqueduct, only 15 yd. in length, is more considerable than that which passes through the second, 40 yd. in length, it is certain that the refrigeration obtained in the first section arises in a very large proportion from the evaporation of the water, which penetrates by filtration through the masonry itself. The refrigeration being quite as much in proportion as that produced by evaporation alone, shares, in the case of the Necker Hospital, the inconvenience existing in the latter method. By channels of a closer kind, such inconveniences might be avoided, and refrigeration might be augmented by using instead of brickwork, metallic tubes of greater conducting power.

On examining the refreshing action of the system, it is easy to see that it is far from being proportionate to the low temperature obtained. Supposing the conduits to be perfectly impermeable, the new air introduced always retains a relative proportion of moisture according to weight. Breathing would, therefore, remain the same, but the relative moisture would augment with the lower temperature, while perspiration would diminish, and thus would partially compensate for the direct refrigeration produced by the lower temperature. On the other hand, the conduits once established, the new air would traverse it in all seasons; the effect would be to bring up the temperature to the average level of the year, with an intensity depending upon their extent and on the varying conducting power of the sides of the conduits. From October to April, the period when the exterior temperature is less than the annual average, it would warm the new air and aid in heating the areas above; but from April to October the contrary would take place. In all parts of France, the mean temperature is less than that maintained in the ventilated hospital wards; the effect, therefore, would be to extend the time of heating to a period when the exterior air is sufficiently warm to retain, after refrigeration, the required temperature; thus it would ever be augmenting it more or less, according to the refrigerative power. As a matter of economy, no doubt there would be regained in winter what is lost in autumn and spring. Any very considerable augmentation, which would be necessary with conduits having a great refrigerative power, would always be of serious inconvenience. Even in the midst of summer, sometimes very cold nights succeed very hot days; the cold night air, still colder in the conduits, would penetrate into the sick wards at too low a temperature, and, following too quickly upon the heat of the day, might cause disastrous effects. The permanent cooling of day and night produced by conduits is, therefore, objectionable. This cause, combined with increase of relative moisture in the fresh air, enters greatly into the inconveniences of the summer ventilation of the Necker Hospital. Hence, instead of endeavouring to increase the cooling power of the subterranean conduits by injection of air, it would be better to reduce them in size, and to render them perfectly water-tight.

On several occasions, attempts have been made to refresh the air by these means. At the Conservatoire des Arts et Métiers, fresh air has been pumped from cellars. In Paris it has been proposed to obtain fresh air from the catacombs; it is true that the temperature of these places is about 52° F. (11° C.), but such air is unhealthy, especially on account of the exhalations from the drains and tombs. Besides, such a system is very complicated.

General Morin has sought to show that it is impossible to depend on any

one of these methods. He experimented upon that system by which it was attempted to cool the air just obtained by the ventilator, by passing it through a water-spray before its introduction. According to Morin, this only produced a lowering of the temperature some 2° C.; it would thus require the use of a very considerable volume of water and a strong motive power to produce an effect most disproportionate to the cost, if specially set up for the purpose. Morin has also condemned the process of passing the air by the sides of metallic casings containing cold water. It is efficacious, but requires the use of very extensive surfaces in proportion to the volume of air cooled, even when the water has previously been cooled by a refrigerating compound, the weight of which in lb. would be twice the number of cub. yd. of air to be cooled.

Such are the difficulties which have led General Morin to propose other methods more immediately imitating the ordinary phenomena of nature, and appearing to him the only methods applicable in all cases, and sufficient for ordinary requirements.

These methods belong to the second class spoken of; they are founded upon direct refrigeration. All previous heating of the air passages is here objected to, as well as of the chambers into which the air is admitted.

One of these methods is to assure a constant draught of air by numerous proportioned air-holes, thus requiring, according to General Morin, who has taken this view into favour, only easy conditions everywhere applicable and very inexpensive. The outlets should be calculated to admit of an entire replacement of the air every half-hour, and the usual swiftness of the issue may be calculated at 0·40–0·50 m. per second. The outlets should be iron-plated outside, so that the action of the sun by heating the plates should increase the draught, their height should be 9 ft. or more above the roofs. The inlets should be as numerous as possible, and open, if feasible, on that side of the orifice not exposed to the rays of the sun; their dimensions should be determined by the condition that air should not pass through them at a greater speed than 0·30–0·50 m. per second, and that the volume of air introduced should suffice to renew the atmosphere of the area at least every half-hour. Windows exposed to the rays of the sun should be furnished with closed blinds or shielded by external blinds, unless they happen to be in the form of a verandah, in which case they should be well watered and covered with linen cloth. For factories and other places lighted with gas, care should be taken to ensure the escape of the products of combustion, either directly to the outside, or, when possible, by chimney ventilators, the action of which they would increase. These chimneys should be provided with registers to moderate their action according to the weather and the seasons.

Such are the terms in which General Morin describes his plan—really only a partial solution of the question, and a very incomplete one.

Nature, which often places the remedy close to the evil, in some cases inexpensively furnishes the means to cool the air. In ascending to the attics of dwelling-houses, the immoderate heat developed by the sun's rays is very perceptible, especially in cases where the roofs are covered with metallic substances. Now, the question is how to turn this heat to account for the introduction of pure air. In 1800, Dr. Anderson suggested the application of such a system. The mode of doing so is very simple. A ventilating chimney (see Fig. 13) is placed on the top of the building, to which abut side props, forming a double ceiling, and having communication by vents in the cornices. The fresh air coming from the cellars enters the room by hollow pillars of vertical props, according to circumstances; and at night, the natural heat of the sun not being available, artificial heat is employed. For museums and meeting-halls, Anderson proposed numerous chimneys having pierced glass frames on the southern side, and closed

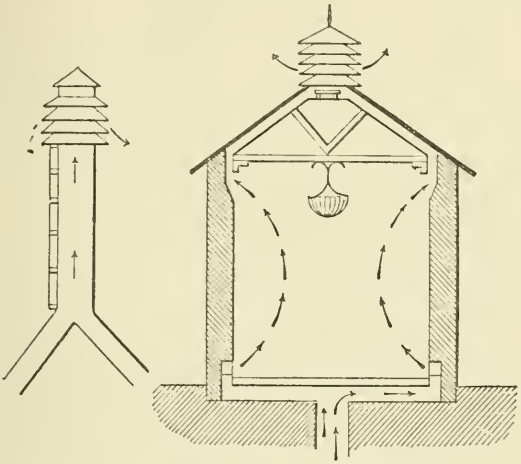
on the 3 other sides; the sun striking on the panes of glass would produce a draught commensurate with the intensity of the heat.

Regnault proposed a similar plan for the buildings of the Exhibition of 1855.

This is a very ingenious method, but like all those named, it can only be applied in a minority of instances.

Another method, recommended especially by Morin, is the imitation of the effect of rain; it is susceptible of being

Fig. 13.



In Switzerland a system has been originated having great analogy with the proposals of Regnault. The inventor, Pradez, started from a very simple point of view. The negro, who is born in the torrid zone, has been endowed by nature with a woolly head of hair, which the sun strikes without reaching the cranium itself. As soon as the air contained in the hair is heated to a greater degree than that of the surrounding air, ventilation takes place of itself in a regular and natural manner; the negro, whose head is bare, is better protected against the rays of the sun than the European with his hat. Pradez has applied this observation to railway stations. By his plan, it is sufficient to protect the metallic roofs against the sun in the same manner that flowers are protected in hothouses against frost, viz. by straw bands of sufficient length and strength.

used almost directly to most edifices and dwellings. According to Morin, it would not require more than $1\frac{1}{2}$ cub. yd. of water per hour to moisten 100 sq. yd. of roofing, and to shelter them from the heat produced by solar radiation. Applied in the morning and during the heat of the day, it not only obviates the heating of roofs, but, as long as the temperature of the water is less than that of the air, it can maintain the interior walls at a temperature far inferior to the latter, and cools the air ascending to the attics. This method of watering being accidental, and only being required during some 60 days of the year, it is easy to see that even for a station as large as that of Orleans, which is 138 yd. by 28, the annual cost would be no more than 40*l.* sterling. It must be admitted, however, that this method, used in some places, is not to be recommended.

It is not only under the immediate roofs that the heat is intolerable during summer, the effects are visible on every floor; and if the heat be more sensibly felt under the roofage itself, it is quite clear that during the hot season there is a necessity for tempering the atmosphere throughout the house. The continual pouring of water on the roof of a house would have little effect upon the inhabitants of the first or ground floors. This refrigeration, on the contrary, would rather tend to arrest the course of the air from the attics, and would thus make atmospheric circulation less rapid. The constant dilapidation of the roof would also follow from a constant pouring of water upon it; it is hardly necessary to urge more by way of demonstration. The Roman architects employed this method in the amphitheatres; one vast cloth spread above the heads of the spectators was continually played upon by water jets. In our days some inventors have tried similar combinations; in some places blinds may be found on which a minute stream of water is playing. To these contrivances, the strange name of hydraulic blinds has been given.

As pure air was sought to be drawn from subterranean localities, so also it was attempted to bring it from the skies; it has been taken from great elevations by means of high chimneys and steeples. At the Lariboisière Hospital, the draught of air on the top of the tower is regulated by a mechanical ventilator fixed on the building. At Guy's Hospital, London, a similar method is used. The air drawn from the summit of the tower, by means of a chimney placed at its base, traverses the wards of the hospital, and is driven out by a second chimney situated in the vaults, producing a constant passage of air in every apartment. However efficacious this method, it must be admitted that in summer the elevated strata of the atmosphere do not possess a temperature materially different from the lower air sufficient to mark the system as a success.

It is evident that these various methods of cooling the air may sometimes be simultaneously employed. This is what has been done in Russia by the engineer Derschau, the apparatus constructed by him offering an ingenious application of the two processes previously described. It is true that this application is expensive; but it was a saloon carriage for an empress, and in such a case expense is no object.

The Derschau system consists, in the first place, of double roofs, painted white, with apertures between to counteract the rays of the sun. To cool the temperature of the carriages, Derschau places in them two cooling apparatus, consisting of two hollow columns in carved oak — Regnault's system. Each column communicates with the outer air by means of an air inlet in the form of a funnel placed beneath the carriage in the direction of the motion of the train, closed with very fine double gauze. As long as the exterior temperature does not exceed 71½° F. (22° C.), the air entering at the lower end of the column and emerging by orifices made under the capital, this apparatus offers a very useful means of ventilation by giving every hour more than three volumes of fresh air in an imperceptible manner. To render the advent of fresh air insensible, the capital is ornamented with hanging plumes. When the external heat is augmented, a metallic cylinder, of less diameter than the column, is fixed inside, and charged with ice and crystallised calcium chloride, in the proportion of 4 and 3 parts. In this case, all the windows being closed, it is possible to lower the temperature 6° below that of the exterior air. It is possible even to attain a greater degree of coolness by modifying the composition of the refrigerating mixture and increasing the size of the apparatus; but then the moisture of the air is so much increased in the carriage as to render it disagreeable, especially when there is too great a difference between the interior and exterior temperature.

This new method of cooling railway

carriages is certainly a step in advance, and superior to all the methods hitherto proposed for the purpose; but, as Derschau himself very judiciously says, it is not to be supposed that it could be applied on a grand scale, in consequence of the expense, the difficulties attendant upon its regulation, and the constant loss of material. They have done better than this, however, in America. In that country, the railway cars are hermetically closed, there is only an opening left in the floor, beneath which is a tank of iced water; at the axles of the wheels a gearing is fixed, which puts a ventilator in motion; the air, passing through a grating, is cooled and purified by the dust being laid. As a refinement upon comfort, this ventilation takes place in winter also, the water then being heated.

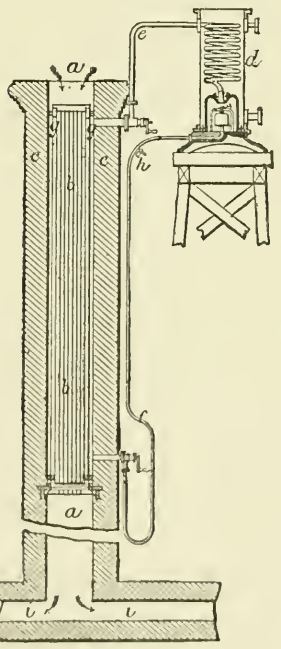
During the last ten years new investigations have been made in the subject, not only in France, but in other countries, and especially in America, where contrivances are continually to be met with, the details of which would be worthy of notice. In France, favourable mention has been made of the apparatus of Piarron de Mondésir. In 1870 this gentleman communicated to the Academy of Sciences a note in which he describes the system for which he had previously taken out a patent for 15 years. It is similar to that which he applied with some degree of success in the Champ de Mars in 1867. At the Exposition of 1867, says the author, during the days of extreme heat, the new air propelled by compressed jets of water through the wooden gratings in the central part of the Palace on the Champ de Mars, arrived clear of dust, and remarkably cooler. This method of preparing fresh air consists of the addition of a minute jet of water in the middle of the compressed motive air jet. The water is literally pulverised by the compressed air, the dust carried off falls into the trough which receives the overplus of the water jet, and in consequence of the intimate mixture of the pulverised water and the air, the latter is at once brought to a temperature as low as the outside air is high. Mondésir goes further, and proposes to apply his system to hospitals. In that which concerns the vitiated air of hospitals, he observes, a jet of compressed air being placed at the base of each ventilating chimney, it would be sufficient to replace the water by a disinfecting fluid in order to obtain a mechanical mixture similar to that just described for fresh air. The organic particles of the vitiated air would probably be precipitated in like manner to the air dust, and received in the trough. The intimate mixture of this disinfecting vapour, and the vitiated air carried off by the outlet chimney, would also guarantee a complete purification of that air.

The Mondésir arrangements have been applied at the establishment of La Belle Jardinière; they have cost much money, and yield very mediocre results, as it is easy to perceive by a visit to that establishment on a hot day in June. Other applications have been tried in factories. His apparatus has not only been tested in domestic economy, but in brewing. The brewers, however, were no more satisfied than the authorities of La Belle Jardinière. It must be admitted, however, that the system was ingeniously conceived. It has done good service, and will do so again.

Tellier discovered, by combining the known laws of nature with the properties of ammonia, a plan, the advantages of which were soon recognised. It is known that *in vacuo* liquids instantaneously give off vapours, reaching their maximum of tension at once. On the other hand, it is also known that if two intercommunicating receivers are maintained at unequal temperatures, there is always vaporisation going on in the colder receiver. The following application is the result of a combination of these two laws with the properties of ammonia. The apparatus represented in Fig. 14 is intended to produce a cooling of the air. It is composed of a chimney *a*, the height of which is variable; at the top of that chimney is

vertically placed the tubular generator *b*, containing a solution of liquefied ammonia to the line *c*. This perfectly isolated receiver is in direct communication with the serpentine condenser *d* by the two pipes *e* and *f*—the receiver *d*

FIG. 14.



is also perfectly isolated. Around the serpentine circulates well-water. No matter what the temperature may be outside the apparatus, it is evident that the interior pressure would be superior to that of the atmosphere; the ammonia would therefore vaporise as well in the chamber *c c g g* as in the tube *f*. The gaseous current being thus formed, sweeping through the interior atmosphere of the tubes and serpentines, would carry before it the air which would be expelled by turning the tap *h*. By means of an indiarubber pipe placed upon the nozzle of this tap, this current would be received in a vase containing water. The air would escape, the ammonia would remain in the water, and when the absorption was complete, and no more bubbles were formed on the surface, it would be seen that all the air had escaped; it would then be necessary to close the tap *h*. This being done, nothing would remain in the interior but the liquefied ammonia, the vapour of which, immediately attaining the maximum of tension, would at once fill the space left empty by the expelled air. If then by any accident the temperature of the generator *b* became higher than that of the condenser *d*, vapour would at once be formed in the receiver *b*, which would proceed to condensation in the receiver *d*, until the balance of temperature was restored. This action would be all the more rapid in proportion to the rapidity with which the vapour is induced in the vacuum; and would be also in proportion to the condensation. Thence there would be a relation between the force of the condensing action in *d*, the promptitude of vaporisation in *b*, and the energy of refrigeration of the body passing in the tubes and round the casing. Now, this body is no other than the atmospheric air freely entering at the orifice *a* and penetrating the tubes, drawn by the increase of density communicated to it by refrigeration, and causing it to descend the chimney. If the surfaces are sufficient, the temperature will remain equal between *b* and *d*; therefore, if the water which reaches the condenser is at 9° or 10° C., the air which emerges at the lower part will have that temperature; descending the chimney *a*, this air passes by the conduits *i* to freely distribute itself in the localities where it is necessary to produce a cooler atmosphere.

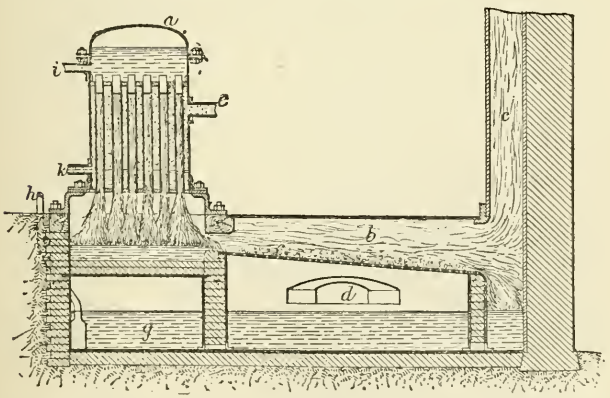
Unquestionably this arrangement, susceptible of modifications according to circumstances, is ingeniously conceived; according to the inventor, it has the merit of cheapness and utility. But it appears somewhat complicated, and this complication materially limits

its application in many instances, especially as we have at the present time an engine which, if not constructed in so original a manner as the engine of Tellier, offers guarantees of success of a similarly weighty kind, and is more economical. The employment of ammonia in itself is an obstacle, among others, to the application of the apparatus. In industrial matters it is constantly desired to find, not elegant combinations, but those which are simple and practical. In some breweries and chocolate factories, this apparatus might be of signal use; but, despite its utility, despite the incontestable claims of the inventor, it cannot be looked upon as a final solution of the question.

The question seems to have been answered by a system founded upon well-known principles, and which has the merit of being universally applicable. This new method is allied to the first class spoken of. In this, both water and a ventilator are again employed, but the dispositions of the system are completely different; to some degree they remind one of the tubes in the Duvoir apparatus. But if the two methods of application are carefully considered, it will be seen that there is a wide difference between them. Duvoir cooled the air by pulverising the water; Nézeraux and Garlandat lay no claim to this pulverisation of water; they content themselves with filtering the air through water, and thus purifying and cooling it. Furthermore, in this new system the simplicity is incontestable, the utility is evident, and the economy is certain.

The original idea is due to Nézeraux, and the apparatus constructed in consequence was jointly perfected by Nézeraux and Garlandat with signal success. The principle already existed in an apparatus previously designed by Nézeraux, and used in the workshops of a well-known constructor. This apparatus, upon which has been bestowed the name of hydro-atmospheric condenser, is composed of two distinct parts, the condenser *a* properly so called, and the refrigerator *b*;—the condenser of a series of tubes assembled between two plates forming part of a cylindrical casing hermetically closed, of a pump which serves at once for circulation and evacuation, and of a chimney *c*, by which the air, saturated with water, escapes (Fig. 15). The refrigerator is formed of a metal plato

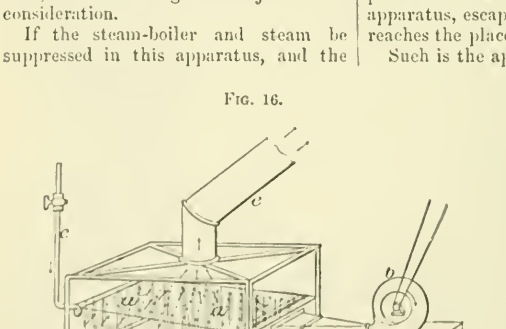
Fig. 15.



pierced with holes of small diameter, and of a ventilator, the current of which passes through the orifice *d*. The steam escaping from the cylinder penetrates to *e*, disperses through the space between the tubes, condenses itself by contact, and produces a vacuum. The water which has just condensed the steam passes above the perforated plate *f*, upon which a current of air is continually in action from above and beneath, which divides the water and instantly cools it; it falls into the tank *g*, whence it is pumped by means of the tube *h* and brought back by *i*; thence it passes uniformly through all the tubes over the whole extent of the refrigerating surface by means of little fluted plugs or similar contrivances at the top of each tube. The conducted steam is drawn off at the base of the apparatus at *k* by means of a pump, to be restored to the feeding tank. Applied to condensers, the refrigerator effects a considerable economy of water, and produces other advantages which it is unnecessary to mention here, not concerning the subject under consideration.

If the steam-boiler and steam be suppressed in this apparatus, and the perforated metallic plate and ventilator be only retained, we obtain another apparatus (Fig. 16).

FIG. 16.



Through the perforated plate *a*, either of metal or some other material, from beneath to above, the ventilator *b*, set in motion by the hand, or, in the case of a more considerable application, by some mechanical motor, keeps up a current of air which passes through the numerous holes of the plate. Above this plate cold water is introduced by the pipe *c*, furnished with a regulating tap; the water passes into a water-pipe, whence it issues uniformly over the plate, which is slanted in such a manner that the thickness of water shall not exceed certain limits; in some cases, ice or chemical solutions, as those of phenic acid, may be substituted, according to the application of the apparatus. The pressure exercised by the propelled air suffices to maintain the water on the surface of the plate, and prevents it passing to the lower part. The water flows slowly on to the plate, and after having passed over and given its coolness to the air which penetrates it, finally reaches the other pipe, by which it runs to the issue at *d*; in most cases this water is again useful for other purposes. As to the cooled air, it penetrates into the upper part of the apparatus, escaping by the tube *e*, and reaches the places where it is wanted.

Such is the apparatus which has been called the *rafraîchissoir* or refrigerator; it is very simple in its construction, nor is its action less remarkable. By this method, we have no operation of the pulverising of water: a system of a complex and often unhealthy nature, particularly if in the hands of ignorant and negligent persons.

The utility of the apparatus consists in the perforated plate, which presents a large plane of action. It is to be remarked that the same air can be reintroduced into the apartment where its beneficent effects are required. In fact, if the fresh air

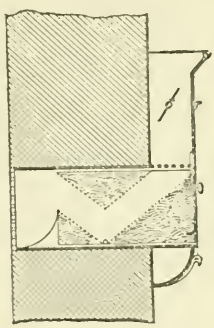
introduced by the apparatus seizes upon the noxious gas, it will be definitively expelled; on the other hand, if it have only conquered some degrees of heat, it can again be taken up by the ventilator and again conducted to the perforated plate, there to leave in the water the hurtful particles, and again recommence its course. Well- or spring-water will supply the liquid at the required temperature; the temperature, in fact, can be lowered to about 53½ F. (12° C.); if a lower temperature is required, this can be obtained by placing ice or frigorific materials on the perforated plate. In all places coolness exists under the surface, no matter what the temperature of the climate; and it is sufficient to simply extract this cold naturally represented by water obtained from a certain depth, to produce fresh and even cold air. Several thousand cub. yd. of air per hour may be cooled; and for this purpose a plate measuring 1 sq. yd. is sufficient. (Jonglet.)

The principle of Mignon et Rouart's process lies in the cooling of the air by contact with refrigerating liquids. They undertook to maintain at a uniform temperature one of the buildings of the Royal Candle Factory at Amsterdam during the hot months of the summer and autumn. This building is over 50 yd. in length by 14½ yd. wide, and 13½ ft. in height, and some 30,000 lb. of oil, at a temperature of about 140° F. (60° C.), are passed in daily to be crystallised into stearic acid. The problem was to maintain during the hot weather a temperature not exceeding 54° F. (12° C.). This was accomplished in the following manner. A concentrated solution of lime chloride prepared with ammonia solution, which gave 60,000 negative calories per hour, was made, and a fan was provided for driving the air at the rate of 20,000 cub. yd. per hour, the capacity of the building being upwards of 3000 cub. yd. A large cylinder was so fitted with internal plates fixed to the sides, and also with a vertical axis carrying plates or paddles arranged so as to pass between the plates affixed to the sides of the cylinder, that when the refrigerating liquid was poured in at the top, and the vertical axis revolved, the mixture was carried by the centrifugal force of rotation against the sides of the cylinder, and being prevented from rising by the plates fixed therein, was forced down to the plate next below, where a similar effect was produced upon it. The result of this arrangement and motion of the apparatus was to produce a finely-separated spray or slowly-falling cascade of the cooling liquid, which constantly filled the interior of the cylinder. The air was drawn by the fan from the lower part of the heated building, and, after passing through the cooling apparatus, was driven in from above. It was found that from the 20,000 cub. yd. driven through it hourly, the apparatus abstracted nearly 60,000 calories, and the result of the experiment was so far satisfactory that during the hottest part of the summer and autumn, the temperature of the building was kept down to an average of 54° F. (12° C.), the readings scarcely ever varying more than 2° or 3°. The inventors do not furnish any details of the cost, so as to compare results with any of the refrigerating machines at present in use; but it will be seen that this method of producing cool air promises to be largely useful in many industries. The lime chloride solution becomes impoverished to a certain extent by use, owing mainly to the absorption of a large amount of watery vapour from the heated air drawn from the building.

Fig. 17 illustrates Boyle's arrangement for cooling the air entering a room in hot weather. It consists of an air inlet tube of bracket form, made of iron. The part which penetrates the hole in the wall has an outer casing, so that a space of about ½ in. is left between, which is packed with a non-conducting substance, for the purpose of preventing the heat from the wall penetrating into the interior of the opening and acting upon the blocks of ice, which are placed in a movable drawer, and kept in position by means of open galvanised iron or copper wire netting. The front of

the drawer is also double, and packed same as casing. The outer air entering through the grating is deflected by a metal shield on to the suspended blocks

FIG. 17.



of ice, and from thence on to the ice at the bottom of the drawer, and thence up the tube into the room. The air is not only cooled, but purified thoroughly from dust.

Cooling and Freezing Water.—Refrigeration, or the artificial production of ice, consists simply in transferring the heat of the water (or other body to be frozen) to some other body. Water at 60° F. (15½° C.) contains an excess of heat beyond that of an equal weight of ice at 32° F. (0° C.) amounting to 170·65 heat units for each lb., therefore, to reduce the water from the first temperature to the second will necessitate the abstraction of that amount of heat from it; to reduce 1 ton of water will require the removal of 62,720 heat units, or 2240 lb. × 28 (the difference between 32° and 60° F.). It would still be water. To convert it into ice, it is further necessary to abstract the latent heat, which determines the liquid state of water, amounting to 142·65 heat units for each lb. of water; or, for 1 ton, 2240 lb. × 142·65 = 319,536 heat units, bringing the total to 382,256 heat units. It is thus evident that about 5 times greater expenditure of power is necessary to transform water at the freezing-point into a solid condition (ice), than is necessary to reduce its temperature from the ordinary point to the freezing-point; and this fact must be borne in mind in the practical application of refrigeration to commercial purposes, where a low temperature will often be as effective as the actual production of ice.

There are 3 physical methods by which temperature may be lowered and ice formed:—(1) By solution of solids; (2) by evaporation of liquids; (3) by expansion of gases. Refrigerating machines may be broadly divided into 2 classes: those which depend on the suitable compression and expansion of air, and those which depend on the condensation and evaporation of a liquid. These two classes correspond with hot-air engines and steam engines respectively, amongst the instruments which convert heat into mechanical work. Each has its peculiar difficulties to contend with, and its own adaptation to particular purposes.

The 3 methods before mentioned will now be described.

1. *By Solution of Solids.*—Heat is absorbed in bringing solids to the liquid condition, and the cold thus produced may prove sufficient to convert water into ice. The salts commonly employed for this purpose are termed "freezing-mixtures." They are chiefly as given on the opposite page.

The best known of the numerous freezing-mixtures that have been hitherto described consists of 3 parts ice, and 1 of ordinary salt. Dissolving concurrently these two substances give a temperature of −5·4° F. (21° C.), the freezing-point of the solution. The melting of only a part of the mixture is sufficient to produce this temperature throughout the mass; and with constant admission of heat, and stirring, the low temperature is maintained till the whole is dissolved. The freezing apparatus of confectioners is well known: a tin pot containing cream, a wooden or metallic vessel enclosing the pot, and the interval filled with ice and salt, which is frequently stirred, that the ice may not

Mixtures	Thermometer sinks: ° F.	Actual Reduction of Temperature: ° F.
(1) 2 parts snow or pounded ice, 1 sodium chloride	from any temperature to −5	..
(2) 5 parts snow or pounded ice, 2 sodium chloride, 1 ammonium chloride	from any temperature .. to −12	..
(3) 24 parts snow or pounded ice, 10 sodium chloride, 5 ammonium chloride, 5 potassium nitrate	from any temperature .. to −18	..
(4) 12 parts snow or pounded ice, 5 sodium chloride, 5 ammonium nitrate	from any temperature .. to −25	..
(5) 3 parts sodium phosphate, 2 ammonium nitrate, 4 diluted mixed acids	from −34 to −50	16
(6) 8 parts snow, 10 dilute sulphuric acid ..	,, −68 to −91	23
(7) 1 part snow, 3 crystallised calcium chloride	,, −40 to −73	33
(8) 5 parts sodium phosphate, 3 ammonium nitrate, 4 dilute nitric acid	,, 0 to −34	34
(9) 1 part ammonium nitrate, 1 water	,, 40 to 4	36
(10) 5 parts ammonium chloride, 5 potassium nitrate, 16 water	,, 50 to 10	40
(11) 1 part snow, 1 dilute sulphuric acid	,, −20 to −60	40
(12) 3 parts snow, 2 dilute nitric acid	,, 0 to −46	46
(13) 8 parts snow, 3 dilute sulphuric acid, 3 dilute nitric acid	,, −10 to −56	46
(14) 5 parts ammonium chloride, 5 potassium nitrate, 8 sodium sulphate, 16 water ..	,, 50 to 4	46
(15) 5 parts sodium sulphate, 4 dilute sulphuric acid	,, 50 to 3	47
(16) 3 parts sodium nitrate, 2 dilute nitric acid	,, 50 to −3	53
(17) 2 parts snow, 3 calcium chloride	,, −15 to −68	53
(18) 3 parts snow, 2 dilute sulphuric acid ..	,, 32 to −23	55
(19) 1 part ammonium nitrate, 1 sodium carbonate, 1 water	,, 50 to −7	57
(20) 8 parts snow, 5 hydrochloric acid	,, 32 to −27	59
(21) 6 parts sodium sulphate, 4 ammonium chloride, 2 potassium nitrate, 4 dilute nitric acid	,, 50 to −10	60
(22) 9 parts sodium phosphate, 4 dilute nitric acid	,, 50 to −12	62
(23) 7 parts snow, 4 dilute nitric acid	,, 32 to −30	62
(24) 1 part snow, 2 crystallised calcium chloride	,, 0 to −66	66
(25) 3 parts snow, 4 calcium chloride	,, 20 to −48	68
(26) 4 parts snow, 5 calcium chloride	,, 32 to −40	72
(27) 2 parts snow, 3 crystallised calcium chloride	,, 32 to −50	82
(28) 3 parts snow, 4 potash	,, 32 to −51	83
(29) 6 parts sodium sulphate, 5 ammonium nitrate, 4 dilute nitric acid	,, 50 to −40	90

sink to the bottom. In a Paris machine, for home use, the agitation of the freezing-mixture is maintained by rotation of the double cylinder containing it and the cream vessel round an axis at right angles to the cylinder's length. Meidinger has constructed a machine based on the observation that a solution of ordinary salt under 32° F. (0° C.) also fuses ice, and, so long as its concentration is maintained, produces the same low temperature as the mixture of salt and ice. He provides a sieve-like vessel, containing salt, to maintain the concentration as the ice melts. The lowering of temperature is uniform throughout the vessel, and no stirring is required. The machine has come largely into use in perfumery.

On the basis of his own experiments, Meidinger has formed a table showing the respective merits of various freezing-mixtures. The following extract contains the most serviceable :—

Mixture.	Decrease of temperature.	Specific heat of the solution.	Volume weight of solution.	Loss of heat units.		To use for 120 c.		
				1 kilo. Mixture.	1 litre Mixture.	Salt kilo.	Water kilo.	Cost *s.*
	C.							
1 ordinary salt, 3 ice	21°	0·83	1·18	125	100	0·5	1·5	0·34 to 0·12
3 cryst. Glauber salt, 2 concd. muriatic acid	37°	0 74	1·31	55	74	2·7	1·8	1·0 to 0·6
2 ammonia nitrate, 1 sal-ammoniac, 3 water	30°	0·70	1·20	42	51	3	3	7·6 to 6·8
3 sal-ammoniac 2 saltpetre, 10 water ..	26°	0·76	1·15	40	46	2·1	4·2	2·6 to 2·2
3 sal-ammoniac, 2 saltpetre, 4 cryst. Glauber salt, 9 water	32°	0·72	1·22	50	61	2·5	2·5	1·8 to 1·6

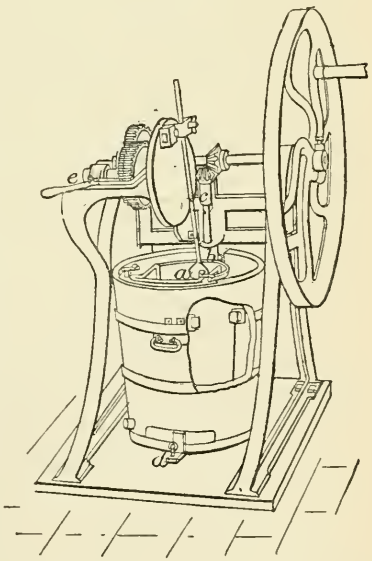
Salt mixtures give much greater lowering of temperature than simple salts, as they dissolve in much less water. Thus, 1 part sal-ammoniac is dissolved in 3 parts water, and lowers the temperature about 19° C.; saltpetre dissolves in 6 parts water, and lowers the temperature about 11° C. (Compare the fourth and fifth on the list.) It will be seen that the salt-ice mixture proves considerably more energetic and cheaper than any of the others so far as use of the materials only once is concerned. The second mixture, too, cannot be restored; nor can the last, easily, on account of the crystallised Glauber salt. Both are comparatively cheap, however. The mixture, in which,

by vaporisation of the solution, the salt is easily renewed in its original condition, ammonia nitrate and sal-ammoniac, is so costly at the first, that it would not do to use it only once. This was the mixture employed in an apparatus first exhibited by Charles at the Paris Exhibition in 1867. The tin vessel containing the substance to be frozen is enclosed in a large wooden vessel containing the freezing-mixture, and is furnished with screw wings, which stir the mixture as the vessel is rotated. Another form is that of Toselli's *glacière Italienne roulante*. The cream or other such substance is enclosed in a conical-shaped vessel suspended in the freezing-mixture, and the outer vessel, enveloped in cloth, is rolled to and fro on the table. None of these machines has found very extensive use. Large masses have to be operated with to obtain even small results; and the sum of operations must generally prove too troublesome in a private house.

As to the question of manufacturing ice on a large scale by means of solution of salt, Meidinger comes to the conclusion that by means of 1 lb. of coal (for restitution of salt used) not more than 2 lb. of ice can be prepared; not to speak of the machine force required for transport of the large quantity of liquid. This is very unfavourable; an ammonia machine will give 4 or 5 times better results. Much improvement is, in the circumstances, hardly to be looked for. It would be necessary to find a salt that, in dissolving, gave a much greater lowering temperature than the mixtures known, and this cannot be expected, since all the known salts have been examined in reference to this point. The real cause of the small productions of such apparatus lies in the fact that restitution of the salt is effected only by change of aggregation (vaporisation), and this involves large expenditure of heat. It may be mentioned that according to experiments by Rudorff, on cold produced by solution of 20 different salts, the two which gave the greatest lowering of temperature were sulphuretted ammonium cyanide, and sulphuretted potassium cyanide—105 parts of the former, dissolved in 100 parts water, produce a lowering of temperature of 31·2° C.; and 130 parts of the latter, in 100 parts of water, as much as 34·5° C.

In making ice cream without machinery, it is always found necessary, after the freezing begins, to beat the cream with a paddle by hand. This facilitates freezing, and at the same time secures a smooth and uniform congelation. In machinery for freezing cream on a large scale, it is desirable that this beating be done automatically, and the closer the action of the paddle imitates the movement imparted by the hand, the better. In the apparatus shown in Fig. 18, this is accomplished

Fig. 18.



by simple mechanism; at the same time, there is improved machinery for rotating, and scraping the interior of the freezing can, the whole being so constructed that a large quantity of ice

cream of excellent quality may be quickly produced by a small expenditure of power. The machine consists of ice tub, can, scrapers to remove the cream from the sides as it freezes, the paddle, and the lid. The tin scrapers, attached at *a*, are bent to conform to the shape of the can, so as not to bear hard on the metal and thus scrape off the tin. The paddle *b* is a bar of galvanised iron, having a tin blade protected by a wooden point. The lid is of iron or tin, with apertures at the flange, so that it may be placed over the scraper supports. The cream, being suitably prepared, is placed in the can, and the tub is filled with ice and salt. The scrapers are inserted in place, and the lid is attached. In the side of the tub is cut a recess, through which a pinion on the vertical shaft *c* enters, and engages a circular rack on the can. When these parts are brought into gear, the tub is held in place by the pin *d*. The vertical shaft *c* is now rotated by bevel gear connected with the main horizontal shaft, which last is turned by the crank shown. The can is thus revolved until the cream becomes quite thick. The paddle, which is secured to the disc on the left, is now thrown into operation by the lever *e*, on moving which, gearing connected with said disc is engaged with gearing on the main shaft. The oscillations of the paddle are continued until the cream becomes stiff and hard. The can is open during the entire operation, and hence its contents are always under the eye of the operator. The inventor (C. L. Dexter, Philadelphia) states that a boy of 14 years can easily make 30 qt. of ice cream at a time without assistance. The cans may hold 12 to 40 qt., and there is no churning of the cream into butter by this apparatus, which may be operated by steam, if desired.

2. *By Evaporation of Liquids.*—The evaporation and recondensation of a liquid may be utilised in 2 ways for the production of cold. Typical of the first method is the well-known laboratory ammonia apparatus of Carré. This consists of two vessels, which may be called *a* and *b*, capable of resisting considerable pressure, and joined by a pipe. The first step in the process is the preparation of liquid ammonia. Vessel *a* contains a solution of ammonia in water, and is artificially heated; *b* is kept cool, and the air is effectually excluded, if there be any leakage, by a water jacket, and in it the ammonia condenses under the pressure caused by the heat of *a*. When sufficient ammonia is condensed, *a* is transferred to a vessel of cold water; the ammonia vapour is rapidly absorbed by the cold water within the vessel *a*. Under the reduced pressure in *b*, the ammonia boils, absorbing much heat and producing considerable cold. The second method is the exact converse of the condensing steam-engine. In the steam-engine, water is converted into steam in a vessel at a high temperature; it expands in the cylinder of the engine, losing a portion of its heat, which becomes useful mechanical work; it then passes to a second vessel maintained at a lower temperature and pressure, in which it is condensed, giving up the balance of the heat it absorbed in the boiler. Imagine the water replaced by ether, the temperature of boiler and condenser appropriately lower, and the direction of rotation of the engine reversed by the application of external power, so that, in fact, it becomes a pump. The ether evaporates in the condenser, absorbing heat and causing cold; the ether steam passes to the pump, where it is compressed, converting mechanical power into heat, and, under the pressure exerted, it is condensed and forced at a higher temperature and pressure into the vessel corresponding with the steam boiler, where it gives up its heat as may be arranged. Upon the choice of the liquid used will depend the pressure and temperatures in the two vessels or chambers. At 32° F. (0° C.), the tension of water vapour is 4·6 *mm.* mercury; of ether, 183·3; of sulphurous anhydride, 1165·1; of ammonia, 3162·9. To produce 1 *litre* (1¾ pint) of water vapour at 32° F. (0° C.), requires 0·0029

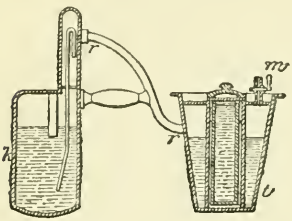
units of heat, the unit being the heat required to raise 1 *kilo.* (2·2 lb.) of water 1° C.; to produce 1 *litre* of ether vapour at the same temperature requires 0·073 units. At 32° F. (0° C.), each stroke of a pump will abstract by ether vapour nearly 30 times as much heat as by water vapour. A glance at these figures shows an obvious advantage in using liquids having low boiling-points; a pump of small capacity will remove a large quantity of heat, but all such substances are too costly to be wasted, and are offensive if any of the vapour escapes. Water presents obvious advantages, in the fact that we need not care what becomes of the vapour when condensed. But the use of water demands the power to produce and maintain a near approach to a perfect vacuum; the barometric pressure must be reduced from the normal of about 760 *mm.* of mercury, to less than 4, and for every unit of heat removed, at least 350 *litres* of vapour must be withdrawn and condensed. Water may be used in either of the methods already mentioned. It may be used in a manner exactly corresponding with Carré's ammonia apparatus, the water taking the place of the ammonia, and some hygroscopic substance, such as sulphuric acid, taking the place of the water, the pressures of course being always very much lower. Or if we can find a sufficiently perfect pump to produce and maintain a vacuum of less than 4 *mm.* of mercury, we may realise the precise reversal of the condensing steam-engine; but to produce any quantity of ice, the pump must not only be very perfect, but have a great capacity. A combination of the two methods answers best. (Dr. Hopkinson.)

In selecting bodies for abstracting and absorbing heat with the object of producing refrigeration on an extensive scale, several points require to be taken into consideration. (1) The first is the amount of latent heat absorbed by 1 lb. of the body in changing its state, being 966·1 heat units for watery vapours, 900 for gaseous ammonia, 364·3 for alcohol vapour, 162·8 for ether vapour. The amount of artificial cold produced will be in inverse ratio: thus the formation of 1 ton of ice will necessitate the evaporisation of about 395⅔ lb. of water, 424¾ lb. of liquid ammonia, 1049¼ lb. of alcohol, or 2348 lb. of ether. (2) The next important consideration is the degree of facility with which the bodies are vaporised, and the range of temperature within which the evaporisation can be readily accomplished, or, in other words, the boiling-point of the body and the tension of its vapour. It is sought to obtain a body having the former as low as is convenient, combined with the latter also moderately low. Many practical difficulties have been encountered through selecting bodies possessing the former quality, without much regard to the latter. Thus, at a temperature of 75° F. (24° C.), which is often exceeded in town waters in warm countries, the tension of liquid ammonia will be 150–160 lb. a sq. in.; methyl chloride, about 80 lb.; methylic ether, 78 lb.; sulphur dioxide (sulphurous anhydride or oxide), 60 lb. These immense pressures necessitate extreme care in the construction of the apparatus, thereby enhancing the cost; and the difficulty of keeping the joints tight often occasions loss of material and reduced production. (3) Equally necessary to be taken into consideration, is the condensation of the vaporised body, in order that it may be used over again. This condensation is effected by means of a supply of cold water. In some industries, and in certain localities, the scale of consumption of water for this purpose is such as to altogether preclude the use of certain machines. (4) The chemical properties of the substances employed must be studied in relation to their action upon the metal or other material with which they will come into contact. Having said so much concerning the general principles and conditions involved in the artificial production of a low temperature, or ice itself, some space may now be devoted to a description of the principal machines devised with this object.

Ammonia machines.—Carré's inter-

mittent portable apparatus, in which ammonia is employed, is shown in Fig. 19. A boiler *k* containing the ammonia is connected by the pipe *r* with the refrigerator *t*, into the well of which

FIG. 19.



are put vessels filled with water to be frozen. The boiler *k* is placed over a portable furnace, and the apparatus is purged of air, which is driven by the evolved gas out at the stop-cock *m*. This being closed, and the refrigerator immersed in a tank of cool water, the temperature of the liquid ammonia is raised to 230°–240° F. (110°–115° C.), at which heat the ammonia is expelled, and condensed in a liquid form in the refrigerator *t*. The boiler being now removed from the furnace, and placed in the water-bath, the temperature of the water in it will fall, and the power of the water to dissolve ammonia will be restored. The gas will be rapidly re-dissolved, reducing the pressure, as the liquid ammonia will evaporate with corresponding rapidity, drawing for its latent heat upon the sensible heat of the water to be frozen. The result will be the complete evaporation of the liquefied ammonia, and the restoration of an aqueous solution in the boiler, of the original strength. Between the ice-pan and the well, is a body of alcohol, which will not freeze, but will act as a conductor. During the refrigeration, the vessel *t* has a non-conducting envelope.

In the large refrigerator, an ammoniacal solution is placed in a boiler and heated in the ordinary way by a fire underneath. The ammonia is given off rapidly as a gas, and is collected at pressure in a coil of pipes placed in a tank, through which a constant stream of cold water runs. The ammonia is here liquefied, both by its own pressure and by the extraction of all heat above that of ordinary cold water. From this liquefied condition, the ammonia will, on removal of the pressure, fly at once into gas. The liquefied gas is then used in a species of water engine or meter, which serves to pump back the re-united ammoniacal solution into the boiler again. The liquefied gas, after having here done its work, immediately on release flies into gas; and this re-evaporated gas is conducted in circuitous tubes through the freezing tanks or chamber. By reason of this sudden re-evaporation of the ammonia, upon release from high pressure, a large quantity of heat is taken up and rendered latent, and this is of course abstracted from surrounding objects, or from the liquid to be frozen. After having served its purpose, the ammonia is led into a chamber, meeting and mixing with the water from the boiler, out of which the ammonia has been evaporated. It is thus re-absorbed, and then pumped, by the water engine before referred to, back again into the boiler. The ammonia thus is continually circulating round; first evaporated by heat, giving the motive power to the arrangement; next becoming liquefied by virtue of its own pressure of 8 to 10 atmospheres, and being cooled by a stream of running water, it then re-evaporates in doing work, thereby causing a large absorption of heat, and effecting the freezing operation. It is lastly remixed with the unaërated water from the boiler, and is pumped back, as a solution, once again into the boiler.

Ether machines.—The ether refrigerator consists essentially of an engine to give the motive power to the various operations. To this engine is attached, probably on the same piston-rod, a vacuum pump. This pump has its suction pipe on the one side attached to the refrigerating vessel, which is partially filled with ether. By reason of the reduction of pressure in this

vessel produced by the pump, a portion of the ether evaporates, being an exceedingly volatile liquid. In evaporating, the ether renders latent a large quantity of heat, thus extracting it from the remainder of the ether, producing a very low temperature. This reduction of temperature is made use of by circulating through the ether in thin pipes, a fluid such as brine, or calcium chloride, which will not freeze at 32° F. (0° C.). This circulating medium is then made use of to freeze water in blocks for commercial purposes. The circulation is effected by means of a suitable pump. On the other side of the main vacuum pump, the volatilised ether is delivered at slight pressure into a pipe, circulating through a large tank through which a constant stream of cold water is flowing. This causes the recondensation of the ether into a liquid, which then falls by gravitation back again into the main refrigerating vessel. Thus a constant circulation, without loss of the ether, is kept up; the heat abstracted in the refrigerator by evaporation on the suction side being carried off by the constant stream of cold water on the delivery side. This is the most usual form, perhaps, of refrigerating machine, and may be represented by that made by Siddeley and Mackay, of Liverpool.

Mixed-liquid machines.—The "binary absorption" system of Tessié du Mothay and A. I. Rossi is one of the most recent developments of the science of producing artificial cold. Experiments on ethers indicated that those formed by the acids, as well as their alcoholic radicals, possess the property of absorbing sulphurous anhydride (sulphur oxide), some of them to the extent of 300 times their volume of gas, in certain conditions, ordinary ether standing first. Upon this fact, the system is founded. The liquid employed is ethylo-sulphurous dioxide, obtained from ordinary ether by saturating with sulphurous oxide gas. This liquid, at a temperature of 60°–65° F. (15°–18° C.), has no pressure, and can be readily kept in glass bottles at 80°–90° F. (27°–32° C.); its tension is only 2–5 lb. Thus a machine charged with it, when stopped, will show no pressure on the gauges, and even a vacuum at rest, if the temperature is low; while with other liquids, even the stoppage of the machine does not prevent the pressure of the vapours inside soon reaching its point of equilibrium with the temperature outside, and even at as low a temperature as 32° F. (0° C.) sulphur dioxide (sulphurous oxide) alone, as used in the Pictet machine, has still 15 lb. a sq. in. of pressure, exerting a constant and increasing pressure on the vessels containing it, and, in case of a small leak starting, causing the entire loss of the charge. What is said here of sulphurous oxide applies with still more force to liquid ammonia, methyl chloride, and methylic ether.

Such a binary liquid as that just mentioned, when evaporated under a vacuum, is resolved into its two constituents, the mixed vapours entering the pump together; then, under a small compression, ether liquefies first, a few lb. pressure being sufficient for it, even with such waters as are met with in tropical climates. The ether thus liquefied absorbs in the condenser the vapours of sulphurous oxide, reconstituting the "binary liquid," and thereby avoiding the excess of mechanical compression, which would otherwise have been necessary to effect this liquefaction of the oxide. Thus, for the work of compression of the pump, is substituted a power of chemical affinity, and absorption of the less volatile absorbent for the vapours of the more volatile. With the advantage of the low pressure of the ether, is combined the advantage of the intensity of cold produced by the volatilisation of the sulphurous oxide, avoiding its drawbacks. In presence of water and the ether, the sulphurous oxide is transformed, not into sulphuric acid, as before, but into "sulphorinic" acid, the action of which acid upon metals is insignificant, if not absolutely nil. The sulphurous acid being an extinctor, relieves the ether of one of the

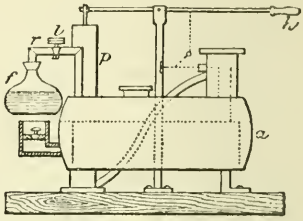
drawbacks to its use, and acting as self-lubricant, renders the greasing of the working parts unnecessary. In a machine making 6 tons of ice daily, the pressures in the condenser in normal and regular working have been 14–15 lb., descending to 10–11 lb. under most favourable conditions, and reaching 20-23 lb. under least favourable conditions. The water used for condensation has been but $\frac{1}{4}$ to $\frac{1}{5}$ of that needed by a Pictet machine of the same capacity. The smallness of pressure required renders the machine much simpler, ordinary valves, &c., sufficing. The New York Ice Machine Co. are working very successfully with the system in the United States.

Recently Rossi and Beckwith have discovered that still better effects are obtainable by a mixture of ammonia and glycerine. The non-volatile glycerine absorbs at low pressure many volumes of ammonia; and when the ammonia is vaporised by the action of a pump, intense cold is produced. The chief advantage claimed for the new compound arises from the utilisation of the great cold-producing power of the ammonia in volatilisation, and the neutralisation of its enormous pressure by its absorption in the glycerine. When the machine is at rest, the pressure is from zero to 15 lb., as against 125 lb. in the ordinary ammonia machine; and when the machine is at work, the pressure is 35 to 50 lb. as compared with a pressure of 225 to 300 lb. in the ammonia machine.

Sulphur-oxide machines.—Sulphuric acid is the medium employed in Carré's domestic apparatus shown in Fig. 20. It consists of a large vessel *a* for holding the concentrated sulphuric acid; an air-pump *p*, with tube connections *r*, adapted to the mouths of the decanters *f*; and a mechanism by which the lever *h* of the air-pump keeps the acid in continual motion; *l* is a stop-cock. This apparatus is useful for cooling drinks.

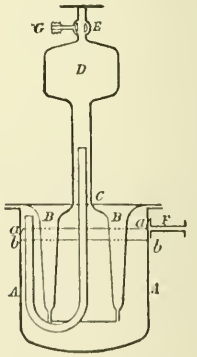
Pictet's machine shown in Fig. 21 is intended more especially for domestic use, about 2 lb. of ice being produced in 10 minutes with the minimum of labour and at slight expense. The freezing liquid is anhydrous sulphurous acid, which rapidly extracts heat from surrounding substances as it

FIG. 20.



vaporises. The apparatus is composed, as usual, of a freezer, a compressing pump, a condenser, and a distributor working under the ordinary conditions;

FIG. 21.



but the freezer has peculiar arrangements for constantly supplying the loss, which however is very slight, of volatile liquid, and so the apparatus remains ready for work without any fresh supply for a long time, say, for example, a year. The freezer consists of 2 superposed chambers, of which the lower is the refrigerator properly so called, working between 2 levels very close together, and of which the upper chamber is the provision made for reserve. The refrigerator consists of a

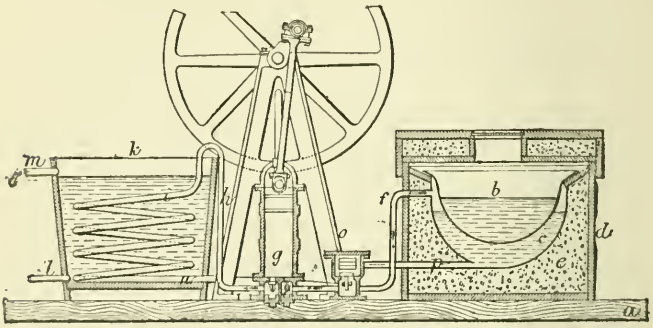
cylindrical receiver A, within which an annular vessel B is formed, and from the centre thereof a column C springs, it communicates with the receiver and is swelled out at the top, forming an enlargement D furnished with stop-cock E having a nozzle G. The receiver has on its side a small passage F. The apparatus is charged by introducing the volatile liquid by G to fill the whole interior capacity of the refrigerator A to the top of the column C, where it is terminated by the stop-cock E; this forms the charge of the apparatus. When the distributing cock is adjusted, which puts the refrigerator in communication with the condenser, all the excess of volatile liquid above the orifice of the pipe F runs into the condenser to the level indicated by the line *a a*. The liquid evaporating from all its free surface, it is necessary to ensure constant equilibrium between the enclosed part of the receiver and the interior of the column C by means of one or more curved tubes of U form, as indicated. The vessel B receives 3 conical annular moulds filled with water to be frozen; they fit almost exactly against the sides of the vessel B —which, however, contains, as is usual, a small quantity of uncongealable liquid, such as glycerine, to ensure the interchange of temperature. When the ice is formed, the moulds are taken out and treated in the usual way to remove the ice. The abstraction of heat necessary to freeze the water in the moulds corresponds to the evaporation of a weight of volatile liquid equal to the difference between the original level *a a* and the level *b b* to which it descends after the freezing. The refrigerator is completely enveloped in a wooden case packed with cork dust to ensure its isolation. Its total capacity for the work proposed, should be 27 pints of volatile liquid, and each of the 3 moulds will contain about 12 oz. of water—say, together, about 2¼ lb.

In Pictet's larger apparatus, the metallic vessels containing the water to be frozen are surrounded by a mixture of glycerine and water. The sulphurous oxide is drawn into a copper tubular refrigerator, the liquid filling the space between the tubes. Here takes place vaporisation, with the consequent production of intense cold, and the temperature of the non-congealable mixture of glycerine and water surrounding the refrigerator is so far reduced that water placed in the metallic vessels immersed in the tank rapidly becomes frozen. A propeller-wheel sends a current of the glycerine solution through the tubes, and thus hastens the refrigeration. The vapour of the oxide is drawn out of the refrigerator by the pump, and forced into the space between the tubes of the condenser. Through these tubes, a stream of cold water is constantly forced; this determines the condensation of the vapours, and the re-liquefied oxide passes into the admission-pipe, and enters again into circulation. A saturated solution of magnesium chloride gives better results than the glycerine mixture. The tension of the oxide vapour varies from about 14·7 to 13 lb.; on the return stroke, the gas is compressed to ¼ or ⅕ its original volume, having its temperature raised to 200° F. (93° C.). The cold water current reduces this temperature to about 61° F. (16° C.) at the outlet; and under a pressure of 3–3½ atmos., the gas resumes a liquid state. It is claimed that 1 lb. of acid produces nearly 1 lb. of ice; and that with a consumption of 22½ tons of coal, 250 tons of ice can be made every 24 hours. The cost is said not to exceed 1 *c.* a *kilo.* (say ½*d.* a lb.). The system is largely adopted in skating-rinks, breweries, &c.

Various - liquid machines. — Some machines can work with any volatile liquid. One of the earliest machines of this kind, and so simple that it can be made at home, was that invented by Jacob Perkins in 1834, and shown in Fig. 22. The apparatus is carried on a wooden base *a*, about 5 ft. long and 2½ ft. wide. At one end is a jacketed copper pan *b*, the interior of which holds the water to be frozen, while the jacket *c* contains the volatile liquid and its vapour. The pan *b* is enclosed in a

wooden box *d*, containing powdered charcoal *e* as a non-conductor. From the top of the jacket *c*, a pipe *f* is led away to the suction-valve of an air-pump *g*,

FIG. 22.



fixed in the middle of the wooden base *a*. From the delivery-valve of this pump, a pipe *h* proceeds to the top of a worm *i* contained in a worm-tub *k*, at the farther end of the base *a*. The worm-tub is supplied with water through an inlet *l* at the bottom, while the escape is at *m*. A pipe *n* in continuation of the lower end of the worm is connected with the under side of a valve-box *o*, in which is a valve loaded to about 15 lb. per sq. in., so that the vapour in the worm is subjected to this pressure, as well as to the cooling influence of the water, and by these means is brought back to a liquid condition. From the upper side of the valve-box a pipe *p* proceeds to the bottom of the jacketed pan, to convey the liquor to it, thus completing the circuit. The box *d* has a double lid lined with charcoal, and a pane of glass at *r*.

Another machine adapted to the use of almost any volatile liquid, whether ammonia, carbon bisulphide, ether, &c., is Holden's, of Philadelphia. It was first designed solely for reducing the temperature of liquids, such as beer, when the liquid to be cooled is allowed to trickle down over the refrigerating coil. It has been widely adopted in American breweries. For the production of ice, additional plant is necessary, consisting of a large tank, and suitable receptacles for the water. A novelty in Holden's arrangement is that the water-holding vessels are introduced at one end of the tank and removed at the other, passing through progressively increasing degrees of cold.

Water machines.—It has long been known that extreme cold can be produced by the rapid evaporation of water in a comparatively perfect vacuum, the heat required for vaporisation being abstracted from the remaining water, which consequently becomes reduced in temperature, and if the process be sufficiently prolonged, actually converted into ice. Machines to carry out this principle have been constructed by Leslie, Carré, and others, but in all these cases the air-pump served only for the rarefaction of the air in the refrigerating compartment, and not for the removal and condensation of the vapour, which had to be entirely absorbed by sulphuric acid, requiring renewal after each operation. Owing to this defect, continuity of action could not be obtained, while the removal and replacement of the acid was not only an expensive operation, but was open to obvious objections from the danger and difficulty of dealing with such a highly corrosive material as oil of vitriol. For these reasons the introduction of vacuum machines has never been general, and in point of fact

they were little known or used, except for producing very small quantities of ice for household purposes and for laboratory experiments, in both of which cases the air-pump was worked by hand. (Engineer.)

Windhausen, and others, who have taken up the practical improvement of his inventions, have brought to a commercial success the manufacture of ice by the evaporation of water at a very low pressure. Their machinery is now working in Berlin and at the Aylesbury Dairy Co.'s premises in St. Petersburg Place, Bayswater. The evaporation of part of the water and freezing of the remainder is effected in 6 vessels of truncated conical form, into which the water is allowed to flow at a regulated speed from 6 tanks above the cones.

The nozzles by which the water flows into the cones are jacketed with the fresh water flowing into the tanks, for the purpose of preventing them from being choked by the ice which would otherwise form there. The cones are closed by hinged lids, which are made perfectly air-tight by means of 2 indiarubber rings, with an annular space between them filled with water. To secure the easy disengagement of the mass of ice when completed, the cones are jacketed with a space into which steam can be admitted. The vacuum is produced and maintained by a compound air-pump. This pump can produce a vacuum of $\frac{1}{2}$ *mm.* of mercury—that is, $\frac{1}{1500}$ part of an atmosphere. The large cylinder is double-acting, and has a diameter of 32 in. and stroke of 20 in., hence a capacity each revolution of 875 pints. The exit valves are self-acting; the entrance valves are actuated mechanically. The small cylinder is single-acting, and has a diameter of 8·8 in. and stroke of 8·4 in.; hence a capacity of 14 pints. The normal speed of the pump is 54 revolutions per minute. In beginning to exhaust with this compound pump, very great force would be required, owing to the great size of the large cylinder in comparison with the small. This inconvenience is avoided by opening a release valve giving communication between the two ends of the large cylinder. When a tolerable exhaustion is attained, this valve is closed, and the pump is worked compound, the large cylinder effecting compression of the residual air or vapour to a certain point, and the small cylinder completing the compression to the tension of the external air. But a small part of the water evaporated passes through the pump; the major portion is absorbed in a cylindrical vessel of boiler-plate. In this, revolves an agitator about a horizontal axis. This vessel is 23 ft. long, and 34 in. diameter, and should be about $\frac{3}{4}$ full, then holding 5250 pints of acid. This vessel is surrounded by water, to prevent the temperature of the acid from rising too much, but for this purpose no very large supply of cold water is needed.

After 3 turns have been worked, the acid is so far diluted that it is well to change it for that which has been concentrated. The air having been admitted, the dilute acid is allowed to run out into a tank. On again exhausting the cylindrical vessel, fresh acid is drawn up from a chamber. The concentration of the acid is effected in a lead-lined vessel, in which is a coil of lead-piping heated by the admission of steam from the boiler. The pressure in this vessel is kept low by means of an ordinary air-pump. No acid pump is needed, as all the moving of acid is effected by the pressure of the air. A complete cycle of work would be approximately as follows:—Start at 12 o'clock, with acid in the reservoir, having a density of 60° B., that is an actual density 1·70, equivalent to 79 per cent. H_2SO_4 to 21 per cent. water; about 40 minutes' pumping is required to produce the vacuum before beginning to run in the water; the water is then admitted in a regulated stream to the cylinders, the pump is kept at work, and the vacuum is maintained at about 3 *mm.* of mercury; about 3780 pints having entered the 6 cylinders, the flow is stopped; 792 lb. has evaporated, and 3960 lb. is formed into ice, and passed through the pump or to the acid. The valves between are now closed. The

lids of the cones are opened, and steam is introduced into the jacket. The 6 blocks, of 6 cwt. each, presently fall down. The lids are again closed, the exhaust valves are opened, and the air is pumped out. The process is repeated with a somewhat slower flow of water, as the absorption by the acid is less rapid. A third time is the air pumped out, and 36 cwt. of ice presently produced. But now the acid is becoming too dilute, its density is reduced to about 51·5° B., that is actually a density of 1·55, indicating 66 per cent. H_2SO_4 and 34 per cent. water. It must be changed for that which has been undergoing concentration during the cycle of 3 turns. The cycle just described produces 108 cwt. of ice, and occupies from start to the next start, and allowing time to change acid, between 8 and 9 hours. Therefore the machine will produce between 15 and 16 tons of ice in 24 hours. The consumption of coals is very small, all told less than 8 per cent. of the weight of ice produced; the acid serves over and over again, indefinitely; the wear and tear of the machine so far appears to be, practically, *nil*. The success of the machine, as regards durability, is largely due to the fact that the sulphuric acid is never so concentrated as to attack lead, and is never so dilute as to attack brass or iron. The condensed water, both from the vacuum pump and from the concentrator pump, did not reveal the slightest trace of acid. In the early days of the machine, the concentrator consisted of a rectangular cast-iron vessel, without any lead lining; it is astonishing how well the cast iron withstood the corrosive action of the hot sulphuric acid when ordinary air was absent. One would expect that there would be some difficulty in keeping the journal of the agitator of the absorber tight, exposed as it is on the interior to acid. This is effected by placing the external portion of the shaft under water. On a large scale, in continuous work, ice can be made at a less cost than 4s. a ton, allowing 10 per cent. on the plant for depreciation, 5 per cent. for interest, and appropriately for other dead charges and contingencies. Though a perfect pump is a necessary adjunct of the machine, the work is nearly all done by the absorption of the acid. The indicator diagrams of the engine employed for driving the pumps gave the following results at the various stages:—With no load, 2·15; during the earlier stage of the exhaustion, with the release valve open, 10·1; after closing the release valve, during the process of freezing, 5·0 in maintaining the vacuum. As the power varies at different stages from 2 to 10 horse, it is clear that by judicious arrangement, 2 complete apparatus could be driven by an engine capable of indicating 12-horse power. A larger quantity of steam is required for heating the absorber from its coil—about 187 pints of water are condensed per hour. From this figure, and from the indicated horse-power, it is easy to see that the consumption of coal may be made very materially less than 8 per cent. (Dr. Hopkinson.)

3. *By Expansion of Gases.*—The atmosphere may be used as the medium by which freezing is effected. This depends on the following natural laws:—When air is compressed, considerable increase of temperature is made sensible, exactly proportioned to the work done in compressing. If, now, this heat be extracted when sensible, upon reduction of pressure and increase to normal volume, the air will be minus the amount of heat which has been abstracted from it by the water. In this way, by compression, cooling, and after re-expansion, intense cold is produced, quite accidentally, by the use of compressed air operating mining engines, the cold of the exhaust air being intense. This production of cold in the one machine is effected by a pump, alternately compressing and again allowing to expand a given quantity of air. When the air is compressed, and its heat is sensibly raised, its position in the machine is determined by a second non-conducting piston, which causes the air when hot and under compression to be always on the one side, and when cold and expanded to be

always on the other. Upon that side at which the heated air is always collected is a hollow cover, through which a constant stream of cold water is running in order to abstract the heat as it is rendered sensible. On the other side to which the expanded and cold air is driven is another hollow chamber with large surface, through which is driven the brine or other solution whose temperature it is required to reduce below freezing-point. The compressed air—always the same quantity, but rising in density as the cold increases—thus acts as a carrier of the heat from the liquid to be frozen to the constant stream of cold water which carries it away. (*Iron.*)

By Giffard's system on this principle, a machine using 18-horse power and burning 792 lb. coal in 10 hours, produces 1 ton of ice in this time. The ice thus costs $\frac{1}{20}d.$ per $2\frac{1}{4}$ lb. with coal at 23*s.* a ton. This price may be reduced to $\frac{1}{2}$, since there are steam engines that do not burn more than $2\frac{1}{4}$ lb. of coal per horse per hour. The same size machine furnishes 2145 cub. ft. per hour of cold air at 32° F. (0° C.). (*Chronique Industrielle.*)

Bell and Coleman's apparatus is designed to overcome the difficulty encountered in the formation of particles of ice during the re-expansion. This is avoided by a more effectual cooling of the compressed air, and by subsequently treating the air so as to separate moisture from it, by subjecting it, before re-expansion, to an atmosphere cool enough to ensure the deposition of any remaining moisture that would be liable to freeze. (See Spons' *Encyclopædia*, pp. 1019–20.)

4. *By Mechanical Means.*—It often happens in towns and where manufactories are crowded together, that the supply of water for condensing purposes is very small, and consequently that it attains an inconveniently high temperature under unfavourable conditions of weather, resulting in the deterioration of the vacuum and a consequent increase in the consumption of fuel. To remedy or to diminish this difficulty, Boase & Miller have brought out a water cooler, which consists of a revolving basket of wire gauze surrounding an inner stationary vessel pierced with numerous small holes, through which the heated water discharged by the air-pump finds its way into the basket, to be thrown out in the form of fine spray to a distance of 20 ft. at each side. The drops are received in a tank, and in their rapid passage through the air are sufficiently cooled to be again injected into the condenser. A cooler having a basket 3 ft. in diameter, making 300 revolutions per minute, and discharging into a tank 40 ft. square, requires 3 to 4 indicated horse-power to drive it, and will cool 300 gal. per minute. The following decrease of temperature has been observed in actual practice:—Water entering at 95° F. fell 20° in temperature; water entering at 100°–110° fell 25°; and water entering 110°–120° fell 30°. The machine with which these trials were made was so placed that the top of the basket was 4 ft. from the surface of the water in the tank. With a greater elevation, better results can be obtained. The advantages claimed for the cooler are that by its means the temperature of the injection water can be reduced, the cost and size of cooling ponds can be diminished, and condensing engines can be employed where hitherto they have not been possible. The apparatus has been for 2 years in operation at several large factories, and there is every reason to believe that its use will extend, as it supplies a real want in a very simple and ingenious manner. Duncan Bros., of Dundee and 32 Queen Victoria Street, London, are the manufacturers.

Cooling Syrups, Solutions, &c.—The moderate cooling of fluids by the effect of a current of cold water is an essential condition of the condensers attached to stills, and this part of the subject will be found discussed under Distillation. Much the same principle is employed in refrigerators for cooling brewers' worts, the object being to attain the maximum exposure of the wort in the least possible time and space.

An equally important but far less developed application of cold to solutions is with a view to separating their valuable portion from the accompanying water. On this subject, Prof. Mills remarks that "theoretically it comes to much the same thing whether you get a substance separated out by means of heat or cold. Cooling is effected by a heat engine, but universally the nature of the substance must have a very material influence, and that alone may decide as to whether we ought to apply heat or cold in any particular case. Ellis has proved the economy in the application of cold in the case of soda sulphate, owing to the peculiar property it has of crystallising out in great abundance at low temperature. In this case, the mere application of heat raises no objection, because the sulphate is an object which you can treat as severely as you please by means of heat. This process, however, is very suggestive in other ways, for example, in dealing with organic bodies, which seem to be specially proper substances for this treatment. Again, in the preparation of solid paraffin wax from the blue oil, cold is constantly employed for the purpose; in fact ever since the greater improvements in the paraffin oil manufacture have been made, this has been systematically applied in order to extract the paraffin. It is surprising that we have not heard more of cold in this way. Why should we not purify such a substance as carbolic acid by dissolving it into some suitable naphtha, and by means of cold separate it again? By this way we might find some means of preparing pure carbolic acid with greater rapidity. Again, polybasic acids might yield similar results. Why not try the effect of cooling solutions of benzoates and tartrates?"

More than 30 years ago, Kneller proposed to concentrate syrups by forcing cold air through them, and his plan was much improved by Chevallier. Sugar made in Chevallier's apparatus rivalled that of the vacuum-pan in every respect. A vessel holding 200 gal. of syrup (comprised of 3 parts sugar to 1 of water) is estimated by Wray to turn out 12 tons of sugar daily. The cost of the apparatus is small; the power required is trifling; the ordinary air of the estate could be used in dry weather, and would entail an insignificant expense for drying in damp weather; and the quality of the sugar is unsurpassed. In 1865, Alvaro Reynoso proposed to rapidly cool the syrup in suitable machines, and thus form a confused mass of particles of frozen water (ice) and dense syrup. The mixture is afterwards separated in centrifugals, and the syrup, deprived of ice, is evaporated *in vacuo* ready for crystallisation. It seems most singular that, in the face of the many drawbacks and great cost incurred by concentration by heat, so little effort is made by sugar-growers to adapt the cooling system to their needs.

Ellis (*Jl. Soc. Chem. Ind.*) has published the results of his experience in the application of cooling to the recovery of soda sulphate from waste liquors. He found that 100 parts of water at 94° F. can hold in solution 412 parts of soda sulphate crystals ($Na_2SO_4+10H_2O$); at 86° F., 184 parts; at 79° F., 110 parts; at 77° F., 98 parts; at 68° F., 58 parts; at 50° F., 23 parts; and at freezing-point only 12 parts; so that a very slight lowering of temperature in the case of a strong solution gives a very considerable yield of crystals; a solution saturated at 94° F. should yield almost 97 per cent. of the crystals if cooled to 32° F. The waste liquor experimented on was about equivalent to a solution saturated at 65° F., and on cooling it down to 40° F., about 2·5 lb. of the salt were always obtained from 1 gal. of liquor; this salt was tolerably pure, and by washing it with a spray of saturated solution of soda sulphate, a salt almost free from foreign bodies was obtained. Some samples which were analysed contained about 0·2 per cent. of common salt and 0·04 per cent. of iron. The next point to be considered is how much heat requires to be abstracted from 1 gal. of the liquor at 65° F. in order to reduce its tempera-

ture to 40° F. and to obtain the crystals from it. We will take as our thermal unit the quantity of heat required to raise 1 lb. of water through 1° F.; 1 gal. of the liquor weighs about 12·5 lb., and has a specific heat of about 0·85, so that $12·5 \times 0·85 \times 25 = 265·6$ thermal units must be extracted in addition to that which is given out by 2·5 lb. of salt while crystallising: this may be taken at 250 thermal units, giving a total of 515·6, to obtain 2·5 lb. of the salt. About 10 times this quantity of heat would require to be supplied to the liquor in order to get the same amount of the salt by evaporating it to dryness. In order to arrive at an idea of the cost of abstracting heat from a solution by artificial means, Ellis consulted Coleman of the Bell-Coleman Refrigerating Company, and he stated that one of his refrigerators which consumed 3 tons of coal in 24 hours could in that time produce cold capable of abstracting 4,000,000 of the above thermal units, which is just about $\frac{1}{10}$ of the corresponding heat which the same weight of coal can supply in practice when applied to evaporation. However, in the case under consideration it would be quite unnecessary to make use of artificial cold for the whole of the reduction of temperature from 65° F. to 40° F., as during a considerable portion of the year, at least half this cooling could be brought about by natural means, and as the yield of crystals is proportionately much greater between 65° F. and 50° F. than between 50° F. and 40° F. it might be found more advantageous not to attempt cooling below 50° F. at all. The liquor contains about 53 parts of salt to 100 parts of water, and by cooling to 50° F. 30 of those parts should be recovered, whereas further cooling to 40° F. would only yield 6–7 parts more of crystals. Ellis was at first inclined to think that the question of the recovery of the salt, economically, could be solved by the use of artificial cold, produced by a mechanical refrigerator of such form as the Bell-Coleman Co. make, but on going into details of cost and working expenses, he feels almost convinced that a similar result could be brought about in another way much more economically, and he proposed the following method for the treatment of this liquor on the large scale. Let us first take a case when the atmospheric temperature is about 50° F. or lower. The liquor could be run away from the precipitating tanks in the copper works into a reservoir of suitable dimensions, where it would be allowed to remain some little time to permit of the solid impurities settling out, and also to allow the liquor to cool down to a certain extent. It could then be made to flow slowly and continuously along a shallow shoot, on the outside of which a current of cooling water ran in the opposite direction to the flow of liquor. In this way all the cooling effect of the water would be utilised, and the liquor would flow away at the end farthest from the reservoir at a temperature the same, or nearly so, as the cooling water, leaving behind it in the shoot all the soda sulphate crystals, which it was unable to hold in solution at that temperature. These could be fished out from time to time without stopping the flow of fresh quantities of liquor, and at once taken to a hydro-extractor, where they could be washed with a spray of saturated solution of soda sulphate, and dried. In this way they would be rendered almost entirely free from foreign bodies, and could then be furnaced and converted into salt cake. This direct treatment could of course only be used when the temperature of the air and water was not much above 50° F., if a fair percentage of the crystals in the liquor were to be recovered, but as this temperature is considerably below the average for a great part of the year, the liquor would require at other times to undergo treatment before entering the reservoir, so that after such treatment it would be of a strength to yield per gallon at the particular temperature as much soda sulphate crystals as a gallon of the original liquor would yield at 50° F. This could of course be brought about by a partial evaporation. Let us suppose, for instance, that the temperature

was at 59° F., and that the liquor was of such strength as to be capable of yielding at 50° F. 2 lb. of crystals from the gallon. From the table of solubilities at different temperatures, it is easily calculated that by evaporating away about 20 per cent. of the water from the liquor, or about 1·4 lb. per gal., a liquor would be obtained which would give per gallon the same yield at 59° F. as 1 gal. of the original liquor would give at 50° F., or if the temperature were as high as 68° F. an evaporation of 40 per cent. or about 2·8 lb. per gal., would again give a liquor which would yield the same result. Thus by varying the amount of evaporation according to the temperature of the air and the yield of salt required, any required result could be arrived at, the limit of course being where the evaporation was carried to the extent of driving off all the water and leaving the dry salts. This was the case in the method of treatment which was formerly resorted to, and which, from the above, appears to be an expensive and, except in most exceptional circumstances, a useless method of procedure, for, by the method of cooling after partial evaporation, when the temperature is at 59° F. only 1·4 lb. of water require to be evaporated away in order to get 1·76 lb. of salt (that is 2 lb. less 12 per cent. for reduction in bulk of the liquor during the partial evaporation) in a fairly pure form, whereas by total evaporation, that is driving off about 7 lb. of water, only 3·75 lb. of a very impure salt is the result, or a little over twice the quantity of salt for 5 times the evaporation. Having evaporated the liquor in part, it could be run into the reservoir and be put through the same treatment as before stated. If the liquor were run from the reservoir at a temperature 30° F. above that of the cooling water, theoretically there would be required less than twice as much cooling water as liquor to be treated, for from 1 gal. of liquor weighing 12·5 lb., $0·85 \times 12·5 \times 30 = 318·75$ thermal units would have to be abstracted in addition to 200 thermal units for the 2 lb. of salt while crystallising out, and 2 gal. of water should be capable of abstracting 600 thermal units, though, of course, in practice, rather more than the theoretical quantity of cooling water would be required. If it is required that only a given quantity of salt is to be allowed to run away in the final waste liquor for each gallon of the original liquor, and we suppose that that quantity is fixed at that which would remain in solution after cooling the original liquor to 50° F.; when the temperature is at 59° F., in place of having to evaporate away 1·4 lb. per gal. we should have to drive off 2·5 lb. of water. Taking into consideration, however, that the liquor is a waste product of practically no value, this latter would not be such an economical way of working as the former, where a gallon of the partially evaporated liquor gave the same yield of salt as a gallon of the original liquor.

The plant required for working up this waste product in this way would be somewhat as follows:—Piping to run the waste liquor to an evaporating pan from the precipitating tanks in the copper works, an evaporating pan (one similar to those used in the evaporation of brine would be suitable), a reservoir, a cooling shoot, a small tank for making saturated solution of soda sulphate, a hydro-extractor for drying and washing the crystals in, with small gas engine to work the same, a furnace for driving off the water of crystallisation and converting the crystals into salt cake, and piping to run away the waste liquor when it left the cooling shoot, and to conduct the cooling water away to be used for any further purpose to which it might be applicable. Ellis concludes with a rough estimate of the cost of working per day of 24 hours, on the supposition that 20,000 gal. were to be treated in that time, and that the average temperature throughout the year is 59° F. For the partial evaporation, about 2 tons of coal would be required at 7*s.* per ton; say 60,000 gal. of cooling water at 4*d.* per thousand; 4 men at 4*s.* and 4 boys at 2*s.*; coal for the furnace, 2 tons at 7*s.*; 4 men at 4*s.*

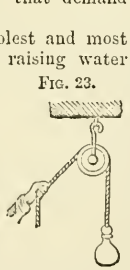
and 4 boys at 2*s.* to attend to the washing and furnacing of the crystals, &c.; gas for the gas engine, &c., 4*s.*; rent of ground, 5*s.*; management, 15*s.*; interest and depreciation on plant at 15 per cent. say on 2000*l.*, taking 300 working days per annum, 1*l.*; giving a total of 7*l.* The production of salt cake for this, taken at about 2 lb. of crystals per gallon, from about 17,000 gal. (after allowing for evaporation), should be over 7 tons, making its cost per ton about 1*l.*

PUMPS AND SIPHONS.—The aim of this article is to describe the various contrivances employed in different industries and in everyday life both at home and abroad, for effecting the removal of liquids from one vessel to another. The most important liquid, of course, is water, but there are several, such as acids, whose corrosive nature renders the ordinary pump useless; and there are others, such as syrups, whose viscosity demands special provision. All these will come under notice; but not the modern pumping engines on a scale interesting only to the engineer, as these may be found in such works as 'Spons' Dictionary of Engineering.' It will be convenient to divide this subject into 2 sections—pumps, and siphons.

Pumps.—Before proceeding to a description of the various forms of pump as now in use, there are many means of raising water that demand some notice.

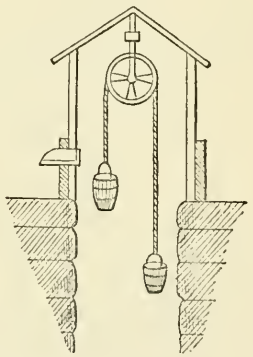
For Water.—The simplest and most rudimentary method of raising water from a depth is by means of a bucket suspended on a cord; the next step in advance is a bucket attached to a pole. These are only adapted for shallow depths. When the depth increases, the weight is too great for direct hauling, and a pulley must be introduced, as in Fig. 23. An improvement on this system, permitting a much larger quantity to be drawn at one time and from greater depths, consists in applying animal power to the free end of the rope, attaching it, for instance, as is very commonly done in India, to a suitably harnessed bullock, which is made to walk along a path of the correct length to suit the depth of draught. By constructing this path with a downward slope away from the well, the animal's weight is made to assist its muscular efforts. This arrangement is the *churus* or *chursah* of India.

Fig. 23.



Another development of the pulley system is seen in Fig. 24, where the full bucket is partly counterbalanced by the empty one, the latter being pulled down to raise the former.

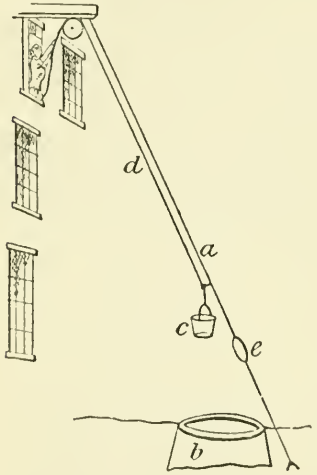
Fig. 24.



In Italy, use is made of a very simple yet ingenious contrivance for raising water from a well to the highest story of a house without descending for the purpose. This is outlined in Fig. 25. One end of a strong iron rod *a* is fixed to the house above the window of an upper landing or passage, the lower end being secured in the ground on the far side of the well *b*, and in a line with its centre. A ring which will slide easily over the rod is fastened to the handle of the bucket *c*, to which also a cord *d* is attached, and carried over a pulley supported above the window. When the cord *d* is slackened, the bucket descends in a diagonal manner till the

ring reaches the stop *c*, which is so arranged that at this point the bucket hangs directly over the centre of the well. On still further slackening the

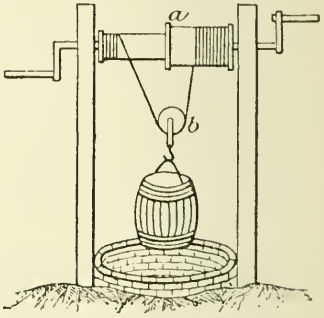
FIG. 25.



cord *d*, the bucket continues to descend, but in a perpendicular direction, to the level of the water. When filled, it is simply hauled up.

A great step in advance of the pulley, for lifting heavy weights, is the windlass, a cylinder made to revolve by crank-handles attached to one or both ends. The rope should have a bucket suspended from each end, so as to be in a manner reciprocating. The Chinese windlass illustrated in Fig. 26 furnishes the means of increasing mechanical energy to almost any extent, and is used to raise water from prodigiously deep wells. The cylinder *a* consists of 2 parts of unequal diameter, to the extremities of which, the ends of the rope are fastened on opposite sides, so as to wind round the 2 parts in contrary directions. As the load to be raised is suspended from a pulley *b*, every turn of the cylinder *a* raises a portion of the rope equal to the circumference of the thicker part, but at the same time lets down a portion equal to that of the thinner, consequently the weight is raised at each

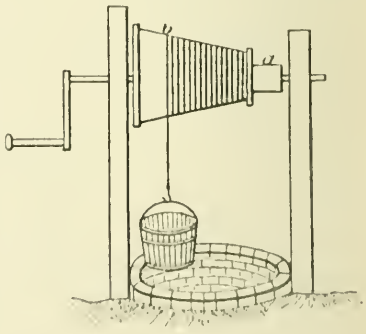
FIG. 26.



turn through a space equal only to half the difference between the circumferences of the 2 parts of the cylinder. Hence the action is slow, but the mechanical power saved is proportionally great.

Another way of lightening the load is illustrated in Fig. 27, and consists

FIG. 27.



in replacing a portion of the cylinder *a* by a "fusee" or cone-shaped drum *b*. One end of the rope is secured to the smaller end of the cone, and the other end of the rope to the bucket. While

the full bucket is at a depth in the well (implying a greater weight to raise on account of the extra rope or chain attached), the winding takes place where the circumference of the fusee is least, and as the length diminishes the rope coils round the greater circumference. Thus while the work is hardest the speed is slowest, and while the work decreases the speed increases.

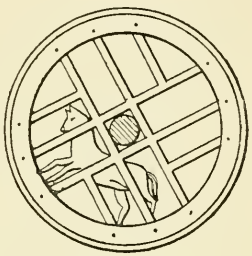
In another modification of the windlass, a cog-wheel is fixed to one end of the cylinder and moved by a pinion that is secured on a separate shaft, and turned by a crank. By proportioning the diameter of the wheel and that of the pinion (or the number of teeth on each) to the power employed, a bucket and its contents may be raised from any depth, since a diminution in the velocity of the wheel from a smaller pinion is accompanied by an increase of the energy transmitted to the cylinder, and *vice versâ*.

The crank handle of the windlass may be replaced by a drum-wheel at one end of the cylinder, of very much greater diameter than the cylinder (say a wheel 12 ft. in circumference and a cylinder 18 in.). The rope that supports the bucket is attached to the cylinder, while a second rope is made to coil round the drum. These ropes run in opposite directions, so that when the bucket is down the cylinder rope is uncoiled while the drum rope is wound up. By taking the free end of the drum rope over the shoulder and walking away from the well, the drum rope is uncoiled and the cylinder rope is wound up, thus raising the bucket.

Sometimes, instead of coiling a second rope on the drum, this latter is made of such dimensions that a horse can work it by walking inside, constituting a tread-wheel, such as is shown in Fig. 28. The capstan-wheel is another form, which was much used in ancient times.

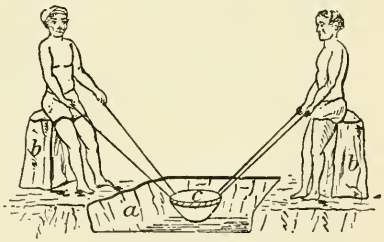
There have next to be considered a class of contrivances dependent on the application of simple leverage. The process illustrated in Fig. 29 is eminently easy, and very widely adopted in Eastern countries, for raising water from shallow depths (2–3 ft.) for purposes of irrigation. It is termed *mental*

FIG. 28.



in Egypt. A small trench *a* is dug on the edge of the tank or stream affording a supply, and an impromptu seat *b* is made of baked earth on each side. The

FIG. 29.



baling vessel *c*, usually a basket of twigs or leaves rendered water-tight by plastering with clay and cowdung, is suspended by 4 cords *d*. The free end of each cord is held in one hand by the operators, who, on launching the bale into the water, lean backwards towards their seats, thus assisting by their own weight in jerking the full vessel out of the trench into a gutter cut to receive and distribute the water. In India, water is lifted in this way, some 12–16 ft. in 3 or 4 stages, by as many pairs of men, at the rate of 1800 gal. an hour.

Swinging gutters seem to have ori-

ginated in the *jantu* of India, which consists of a hollow trough of wood, about 15 ft. long, 6 in. wide, and 10 in. deep, placed on a horizontal beam lying on bamboos fixed in the bank of a pond or river. One end of the trough rests upon the bank, where a gutter is prepared to carry off the water, and the other end is dipped into the water by a man standing on a stage, who plunges it in with his foot. A long bamboo with a large weight of earth at the farther end is fastened to the end of the *jantu* next the river, and, poising up the *jantu* full of water, causes it to empty itself into the gutter. This machine raises water 3 ft., but by placing a series of them one above another, the water may be raised to any height. Water is thus conveyed over rising ground to the distance of more than a mile. Fig. 30 shows the

FIG. 30.

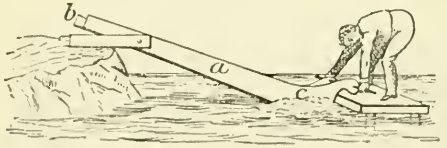
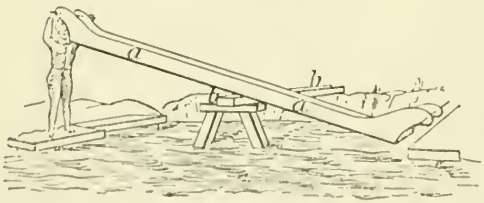


FIG. 31.



mode of working a single gutter, without the aid of a lever pole. *a* is a trough whose open end *b* rests on the bank over which the water is to be elevated; the other end *c* is closed to retain the water entrapped by raising it. Fig. 31 represents an improvement, being a double gutter *a* placed across a trough *b* to receive the water. The gutter *a* is divided by a partition in the centre, on each side of which partition holes are made in the floor of the gutter to let out the water into *b*.

FIG. 32.

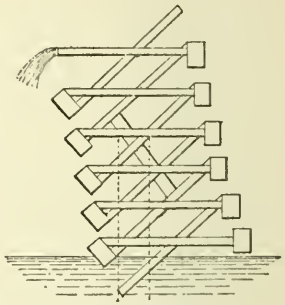


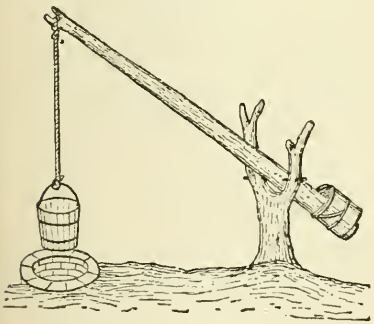
Fig. 32 is a further development, termed a pendulum or set of swinging gutters, raising water by their pendulous motion. The terminations at bottom are scoops, and at the top are open pipes; intermediate angles are formed with boxes and flap-valve, each connected with 2 branches of pipe. The so-called Dutch scoop, Fig. 33, is much used in Holland for raising water over low dykes. It is a kind of box shovel *a* suspended by cords *b* from a triangular frame *c*, and worked by an operator standing on the plank *d*, and thrusting the scoop into the water by means of the handle *e*.

Perhaps the most widely used contrivance for drawing water from wells is that shown (in one of its many forms) in Fig. 34. It is the "swape," "sweep," or "swip" of English chroniclers since Anglo-Saxon times, and is now known to Australian gold-diggers as a "hand whip," the term being probably a corruption of "swip"; it is the *shadoof* or *chadous* of Egypt. Its numerous modi-

fications throughout the world differ only in minor details; the leading principle in all is that the counterpoise shall be about equal to ½ the weight to be raised. In Japan, ropes are attached to the counterpoise for pulling down when elevating the bucket.

FIG. 33.

FIG. 34.



The Hindoos use a modified form of swape, Fig. 35, in which a man's weight is utilised in raising the bucket. The lever is a split tree-trunk, ridged to form steps, and provided with a bamboo railing. As the man walks to and fro, the arm carrying the bucket is alternately lowered and raised, a second man emptying the bucket as fast as it rises. This is termed a *paecottah* or *picota* in Bengal.

FIG. 35.

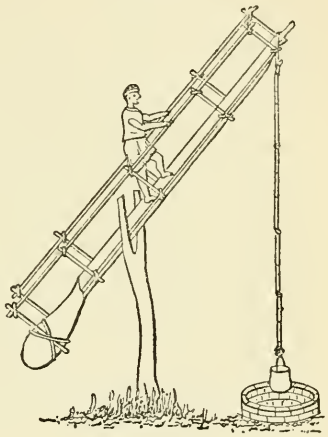
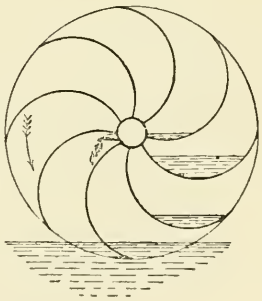


FIG. 36.



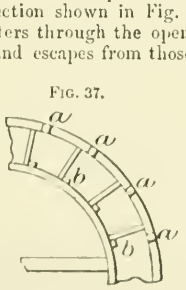
Scoop-wheels assume several different forms, but consist essentially of a number of semicircular partitions between the closed sides of a wheel, extending from the axle to the circumference, as in Fig. 36, which is the pattern used in draining the Lincolnshire fens. As the wheel revolves in the direction of the arrow, the extremities of the partitions dip into the water

and scoop it up; and as they ascend, they discharge into a trough placed under one end of the shaft, which is hollowed into as many compartments as there are partitions or scoops.

The Chinese scoop-wheel has a number of buckets attached to the periphery of a huge wheel, which is composed of 3 bamboo rings of unequal diameter, arranged so as to form a frustum of a cone, the smallest ring to which the open ends of the buckets (sections of bamboo 4 ft. long and 2–3 in. diam.) are attached, being next the bank over which the water is conveyed. By this arrangement, the contents of the buckets are necessarily discharged into the gutter as they pass the end of it. When employed to raise water from running streams, they are propelled by the current in the usual way—the paddles being formed of woven bamboo. The size of these wheels varies from 20 to 70 ft. in diameter. Some raise over 300 tons of water per 24 hours, or 150 tons 40 ft. high in the same time. Being built almost exclusively of bamboo, they combine economy, strength, lightness, and efficiency in a wonderful degree.

In the Egyptian *noria*, instead of vessels being attached to the wheel, the wheel rim itself is made hollow and divided into compartments, as seen in the section shown in Fig. 37. The water enters through the openings *a* in the rim and escapes from those *b* in the side.

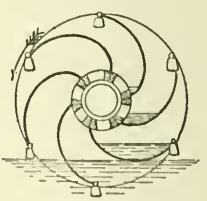
FIG. 37.



The Spanish wheel is a very light framework disc having a series of pots secured to the periphery. Its most remarkable feature is that motion is given to the wheel by a system of spokes on its axle working into other spokes on a vertical shaft—one of the earliest forms of cog-wheel.

The fault common to all the wheels hitherto described is that they begin to discharge before reaching the channel provided for the reception of the water, and waste power in carrying much of the water higher than it is required. These two defects are well remedied in the Persian wheel, by suspending the buckets so that they are free to swing, thus hanging perpendicularly throughout their course, until they reach the receiving trough, when they are made to tilt and discharge their contents at once by coming into contact with a stop on the trough. Fig. 38 illustrates

FIG. 38.

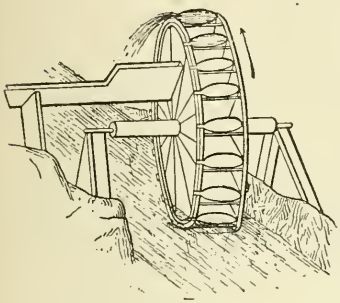


another form of Persian wheel having both scoops and buckets. It has a hollow shaft and curved floats, at the extremities of which are suspended buckets or tubs. The wheel is partly immersed in a stream acting on the convex surface of its floats; and as it is thus caused to revolve, a quantity of water will be elevated by each float at each revolution, and conducted to the hollow shaft, at the same time that one of the buckets carries its fill of water to a higher level, where it is emptied by coming into contact with a stationary pin placed in a convenient position for tilting it.

In Fig. 39 is represented a machine of ancient origin, still employed on the river Eisach, in the Tyrol, for raising water from the stream. The current keeping the wheel in motion, the pots on its periphery are successively immersed, filled, and emptied into a trough above the stream.

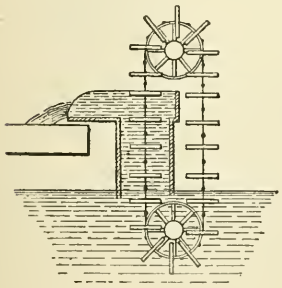
The bucket wheel being incapable of reaching water at any considerable depth, led to the adoption of a modified form, called a chain of pots, the buckets being attached to chains working over the wheel instead of to the wheel itself. In Egypt, under the name

FIG. 39.



of *sakia*, this machine is in common use, and its employment extends throughout Spain and the East generally, power being applied by a vertical shaft and cog-wheels, moved by bullocks. It is nothing less than a modern "elevator" worked by animal power instead of steam.

FIG. 40.



Another form of elevator or chain pump is illustrated in Fig. 40, lifting water by continuous circular motion. Wooden or metallic discs, carried by an endless chain, are adapted to a water-tight cylinder, and form with it a succession of buckets filled with water. Power is applied at the upper wheel.

The chain pump known as the Chinese or Californian pump, represented in Fig. 41, is in common use in alluvial gold diggings in America and Australia. A rectangular box, about 10 in. by 3 in. inside measurement, and varying from 10 to 30 ft. long, according to need, is traversed by an endless flexible band or belt of canvas, on one side of which are securely fixed at intervals wooden discs nearly as large as the inside of the box. The lower end of the box is furnished with a roller, around which the belt passes, and is immersed in the water to be raised from the pit, while the upper end delivers the water into a trough or launder, by which it is carried away. At the upper end the belt passes round a second roller or drum, which is made to revolve by either hand- or water-power. In Fig. 41 is shown one driven by a water wheel: *a* is a flat wooden pipe or box, open at both ends, forming the pump; *b*, the pump-belt, carrying the wooden stops, faced with leather, called the buckets or suckers *d*; *c*, the ends of the belts joined together by lacing; *h*, the drum fixed on the axle of the water wheel *w* and turning with it; *i*, entrance of water to be pumped up; *e*, exit of same; *f*, launder or race to convey the water from the pump and wheel clear of the working; *g*, sluice-box set in a head-race to bring the water necessary for driving the wheel. The Chinese diggers make even the belt of wood, hinging short sections together by wooden pins.

An application of the Archimedes screw to the raising of water is shown in Fig. 42, the supply stream being the motive power. The oblique shaft of the wheel has extending through it a spiral passage, the lower end of which is immersed in water, and the stream, acting upon the wheel at its lower end, produces its revolution, by which the

water is conveyed upward continuously through the spiral passage, and discharged at the top.

A reciprocating lift for wells is indicated in Fig. 43. The top part represents a horizontal wind-wheel on a shaft which carries a spiral thread. The coupling of the latter allows a small vibration, that it may act on one worm-wheel at a time. Behind the worm-wheels are pulleys, over which passes a rope which carries a bucket at each extremity. In the centre is a vibrating tappet, against which the bucket strikes in its ascent, and which, by means of an arm in a step wherein the spiral and shaft are supported, traverses the spiral from one wheel to the other, so that the bucket which has delivered its water is lowered, and the other is raised.

FIG. 41.

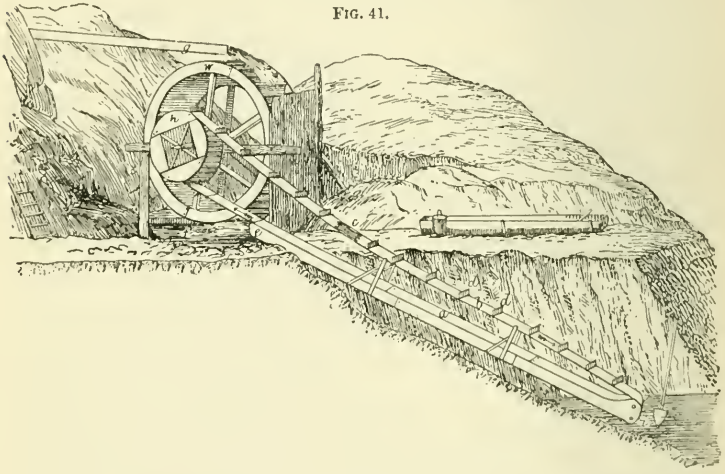


FIG. 42.

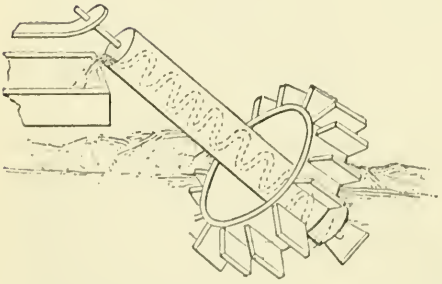
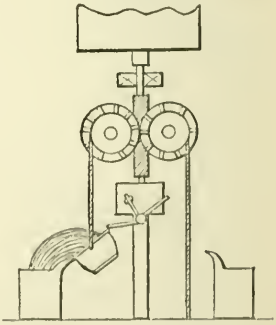


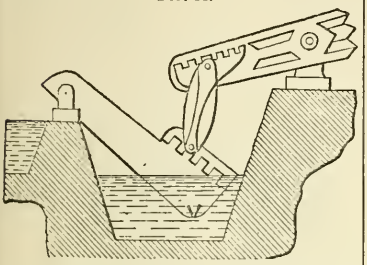
FIG. 43.



Fairbairn's baling scoop for elevating water short distances is illustrated in Fig. 44. The scoop is connected by a

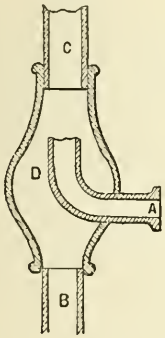
pitman with the end of a lever or of a beam of a single-acting engine. The distance of the lift may be altered by placing the end of the rod in the notches shown.

FIG. 44.



Brear's bilge ejector, for discharging bilge-water from ships, or for raising and forcing water under various circumstances, is represented in Fig. 45; D is

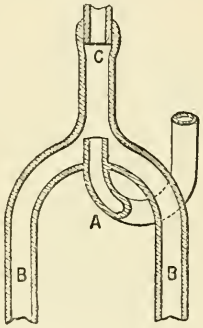
FIG. 45.



a chamber having attached a suction-pipe B and discharge-pipe C, and having a steam-pipe entering at one side, with a nozzle directed towards the discharge-pipe. A jet of steam entering through A expels the air from D and C, produces a vacuum in B, and causes water to rise through B and pass through D and C in a regular and constant stream. Compressed air may be used as a substitute for steam.

Fig. 46 is another apparatus operating on the same principle, and is termed Lansdell's steam siphon pump; A is the jet pipe; B, 2 suction-pipes having a forked connection with the discharge-pipe C.

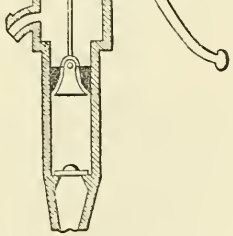
FIG. 46.



The steam-jet pipe entering at the fork offers no obstacle to the upward passage of the water, which rises in an unbroken current.

Fig. 47 is a common lift-pump. In the up-stroke of the piston or bucket, the

FIG. 47.

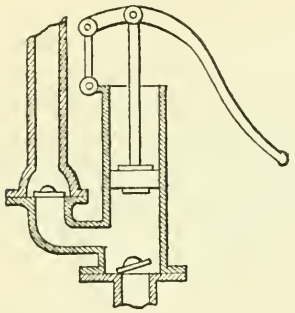


lower valve opens and the valve in the piston shuts; air is exhausted out of the suction-pipe, and water rushes up to fill the vacuum. In the down-stroke, the lower valve is shut, the valve in the piston opens, and the water simply passes through the piston. The water above the piston is lifted up, and runs

over out of the spout at each up-stroke. This pump cannot raise water over 30 ft. high.

Fig. 48 is an ordinary force-pump with 2 valves. The cylinder is above

FIG. 48.



water and is fitted with a solid piston; one valve closes the outlet-pipe and the other the suction-pipe. When the piston is rising, the suction-valve is open, and water rushes into the cylinder, the outlet-valve being closed. On the descent of the piston, the suction-valve closes, and water is forced up through the outlet-valve to any distance or elevation.

FIG. 49.

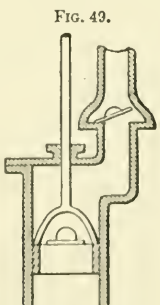
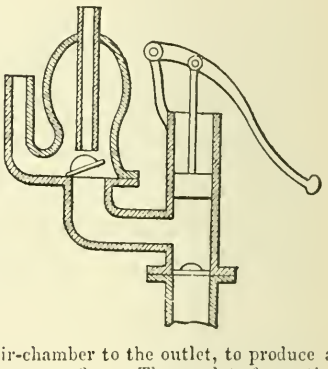


Fig 49 is a modern lift-pump operating in the same manner as that shown in Fig. 48, except that the piston-rod passes through the stuffing-box, and the outlet is closed by a flap-valve opening upwards. Water can be lifted to any height above this pump.

Fig. 50 is a force-pump similar to that in Fig. 48, with the addition of an

FIG. 50.



air-chamber to the outlet, to produce a constant flow. The outlet from the air-chamber is shown at 2 places, from either of which water may be taken. The air is compressed by the water during the downward stroke of the piston, and expands and presses out the water from the chambers during the up-stroke.

Fig. 51 is a double-acting pump. The cylinder is closed at each end, and the piston-rod passes through the stuffing-box on one end; the cylinder has 4 openings covered by valves, 2 for admitting water and 2 for its discharge. A is the suction-pipe; B, discharge-pipe. When the piston moves down, water rushes in at suction-valve 1 on the upper end of the cylinder, and that below the piston is forced through valve 3 and discharge-pipe B. On the piston ascending again, water is forced through discharge-valve 4 on the upper end of the cylinder, and water enters the lower suction-valve 2.

Fig. 52 is a double lantern-bellows pump. As one bellows is distended by the lever, air is rarefied within it, and

water passes up the suction-pipe to fill the space; at the same time the other bellows is compressed, and expels its contents through the discharge-pipe,

FIG. 51.

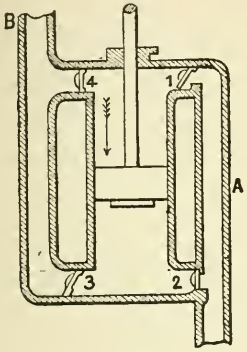
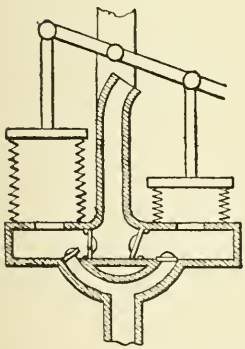


FIG. 52.



the valves working the same as in the ordinary force-pump.

Fig. 53 is an old rotary pump. The lower aperture is the entrance for water, and the upper for its exit. The central part revolves with its valves, which fit accurately to the inner surface of the outer cylinder. The projection shown in the lower side of the cylinder is an abutment to close the valves when they reach that point.

Fig. 54 is Cary's rotary pump. Within the fixed cylinder is placed a revolving drum B, attached to an axle, a heart-shaped cam *a*, surrounding the axle, being also fixed. Revolution of

FIG. 53.

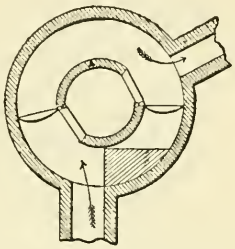
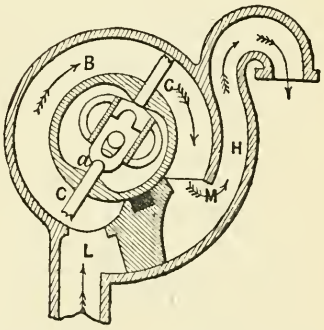


FIG. 54.



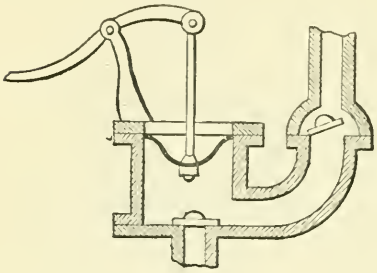
the drum causes sliding pistons *c* to move in and out, in obedience to the form of the cam. Water enters and is removed from the chambers through the ports L M, as indicated by arrows. The cam is so placed that each piston is, in succession, forced back to its seat when opposite E, and at the same time the other piston is forced fully against the inner side of the chamber, then driving before it the water already there into the exit-pipe H, and drawing after it through the suction-pipe the stream of supply.

In Fig. 55 a flexible diaphragm is

employed instead of bellows, the valves being arranged as usual.

Having described the best known means of raising water under various

FIG. 55.



circumstances, there remains to enter with more detail into the construction, capacity, and working of the 3 kinds of common pump in everyday use—i. e. (1) the lift-pump for wells not over 30 ft. deep, (2) the lift and force for wells under 30 ft. deep, but forcing the water to the top of the house, and (3) the lift and force for wells 30–300 ft. deep.

The working capacity of a pump is governed by the atmospheric pressure, which roughly averages 15 lb. per sq. in. It is also necessary to remember that 1 gal. of water weighs 10 lb. The quantity of water a pump will deliver per hour depends on the size of the working barrel, the number of strokes, and the length of the stroke. Thus if the barrel is 4 in. diam., with a 10-in. stroke, piston working 30 times a minute, then the rule is—square the diameter of the barrel and multiply it by the length of stroke, the number of strokes per minute, and the number of minutes per hour, and divide by 353, thus:—

$$\frac{42 \text{ in.} \times 10 \text{ in. stroke} \times 30 \text{ strokes} \times 60 \text{ minutes}}{353}$$

= 815 gal. per hour. About 10 per cent. is deducted for loss. The horse-power required is the number of lb. of water delivered per minute, multiplied by the height raised in ft., and divided by 33,000. Thus:—

$$\frac{815 \text{ gal.} \times 10 \text{ lb.} \times 30 \text{ ft. lift}}{33{,}000} = 7{\cdot}4 \text{ H.P.}$$

FIG. 56.

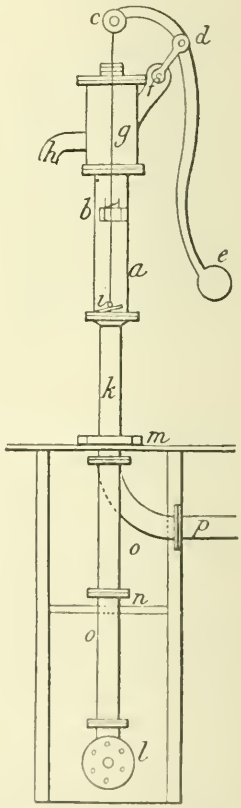


Fig. 56 shows a vertical section of the simple lift-pump. *a* is the working barrel, bored true, to enable the piston or bucket *b* to move up and down, air-tight. The usual length of barrel in a common pump is 10 in. and the diameters are 2, 2½, 3, 3½, 4, 5, and 6 in.; a 3-in. barrel is called a 3-in. pump. The stroke is the length of the barrel;

but a crank, 5-in. projection from the centre of a shaft, will give a 10-in. stroke at one revolution; but in the common pump shown, use is made of a lever pump-handle, whose short arm *c d* is about 6 in. long, and the long arm or handle *d e* is usually 36 in., making the power as 6 to 1; *f* is the fulcrum or prop. Improved pumps have a joint at *f*, which causes the piston to work in a perpendicular line, instead of grinding against the side of the barrel. The head *g* of the pump is made a little larger than the barrel, to enable the piston to pass freely to the barrel cylinder; in wrought-iron pumps, the nozzle is riveted to the heads, and unless the head is larger than the barrel these rivets would prevent the piston from passing, and injure the leather packing on the bucket. The nozzle *h*, fixed at the lower part of head, is to run off the water at each rise of the piston. There is 1 valve *i* at the bottom of the barrel, and another in the bucket *b*.

The suction-pipe *k* should be $\frac{2}{3}$ the diameter of the pump barrel. A rose *l* is fixed at the end of the suction-pipe to keep out any solid matter that might be drawn into the pump and stop the action of the valves. The suction-pipe must be fixed with great care. The joints must be air-tight: if of cast flange-pipe, which is the most durable, a packing of hemp, with white and red lead, and screwed up with 4 nuts and screws, or a washer of vulcanised rubber $\frac{3}{4}$ in. thick, with screw bolts, is best. If the suction-pipe is of gas-tube, the sockets must all be taken off, and a paint of boiled oil and red-lead be put on the screwed end, then a string of raw hemp bound round and well screwed up with the gas tongs, making a sure joint for cold water, steam, or gas.

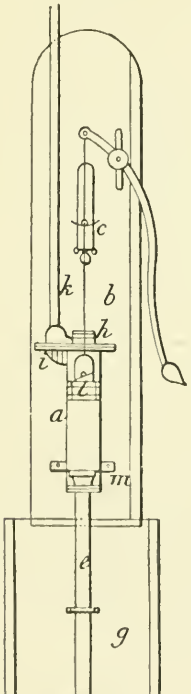
Many plumbers prefer lead pipe, so that they can make the usual plumbers' joint. The tail *m* of the pump is for fixing the suction-pipe on a plank level with the ground. Stages *n* are fixed at every 12 ft. in a well; the suction-pipe is fixed to these by a strap staple, or the action of the pump would damage the joints. There are two plans for fixing the suction-pipe; (1) in a well *o* directly under the pump; (2) the suction-pipe *p* may be laid in a horizontal direction, and about 18 in. deep under the ground (to keep the water from freezing in winter) for almost any distance to a pond, the only consideration being the extra labour of exhausting so much air. In the end of such suction-pipe *p* it is usual to fix an extra valve, called a "tail" valve, to prevent the water from running out of the pipe when not in use. The action is simply explained. First raise the handle *e*, which lowers the piston *b* to *i*; during this movement the air that was in the barrel *a* is forced through the valve in the piston *b*; when the handle is lowered, and the piston begins to rise, this valve closes and pumps out the air; in the meantime the air expands in the suction-pipe *k*, and rises into the barrel *b* through the valve *i*; at the second stroke of the piston this valve closes and prevents the air getting back to the suction-pipe, which is pumped out as before. After a few strokes of the pump handle, the air in the suction-pipe is nearly drawn out, creating what is called a vacuum, and then as the water is pressed by the outward air equal to 15 lb. on the sq. in., the water rises into the barrel as fast as the piston rises; also the water will remain in the suction-pipe as long as the piston and valves are in proper working order.

The following table of dimensions for hand-worked simple lift-pumps will be found useful:—

Height for Water to be raised.	Diam. of Pump Barrel.	Water delivered per Hour at 30 Strokes per Min.	Diam. of Suction Pipe.	Thickness of Well Rods for Deep Wells.
ft.	in.	gal.	in.	in.
14	6	1640	4	1
20	5	1140	3	1
30	4	732	$2\frac{1}{2}$	$\frac{7}{8}$
40	$3\frac{1}{2}$	555	$2\frac{1}{2}$	$\frac{3}{4}$
50	3	412	2	$\frac{3}{4}$
75	$2\frac{1}{2}$	260	2	$\frac{5}{8}$
100	2	183	$1\frac{1}{2}$	$\frac{5}{8}$

Fig. 57 shows a lift- and force-pump suitable for raising water from a well 30 ft. deep, and forcing it to the top of a house. The pump barrel *a* is fixed to a strong plank *b*, and fitted with

FIG. 57.



"slings" at *c* to enable the piston to work parallel in the barrel, a guide rod working through a collar guiding the piston in a perpendicular position. *d* is the handle. The suction-pipe *e* and rose *f* are fixed in the well *g* as already explained. At the top of the working barrel is a stuffing-box *h*, filled with hemp and tallow, which keeps the pump-rod water-tight. When the piston is raised to the top of the barrel, the valve *i* in the delivery-pipe *k* closes, and prevents the water descending at the down-stroke of the piston. The valve in the bucket *l*, also at *m* in the barrel *a*, is the same as in the common pump. The pipe *k* is called the "force" for this description of pump.

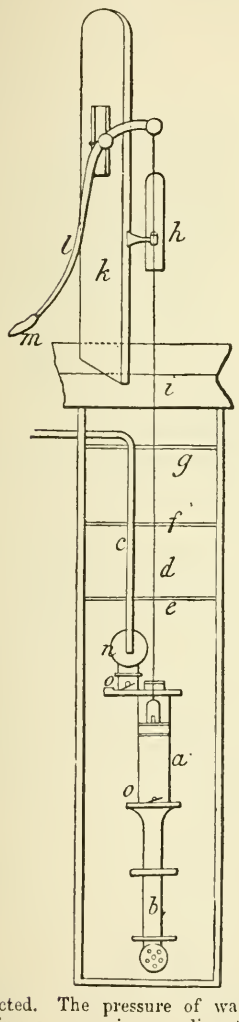
Fig. 58 shows a design for a deep well pump, consisting of the usual fittings—viz., a brass barrel *a*, a suction-pipe with rose *b*, rising main pipe *c*, well-rod *d*, wooden or iron stages *e f g*, and clip and guide pulleys *h*. The well-rod and the rising main must be well secured to the stages, which are fixed every 12 ft. down the well. An extra strong stage is fixed at *i*, to carry the pump—if of wood, beech or ash, 5 ft. × 9 in. × 4 in.; the other stages may be 4 in. sq.

The handle is mounted on a plank *k* fitted with guide slings, either at right angles or side-ways to the plank. The handle *l* is weighted with a solid ball-end at *m*, which will balance the well-rod fixed to the piston. By fixing the pump barrel down the well about 12 ft. from the level of the water, the pump will act better than if it were fixed 30 ft. above the water, because any small wear and tear of the piston does not so soon affect the action of the pump, and therefore saves trouble and expense, as the pump will keep in working order longer. It is usual to fix an air-vessel at *n*. The valves *o* are similar to those already described. In the best-constructed pumps, man-holes are arranged near the valves to enable workmen to clean or repair the same, without taking up the pump. Every care should be given to make strong and sound joints for the suction-pipe and delivery-pipe, as the pump cannot do its proper duty should the pipes be leaky or draw air.

To find the total weight or pressure of water to be raised from a well, reckon from the water level in the well to the delivery in the house tank or elsewhere. For example, if the well is 27 ft. deep, and the house tank is 50 ft. above the pump barrel; then you have 77 ft. pressure, or about 39 lb. pressure per

sq. in. That portion of the pipe which takes a horizontal position may be

FIG. 58.



neglected. The pressure of water in working a pump is according to the diameter of the pump barrel. Suppose the barrel to be 3 in. diam., it would contain 7 sq. in., and say the total height of water raised to be 77 ft., equal to 39 lb. pressure, multiplied by 7 sq. in., is equal to 539 lb. to be raised or balanced by a pump handle; then if the leverage of the pump handle were, the short arm 6 in. and long arm 36 in., or as 6 to 1, you have $(539 \times 1) \div 56 =$ 90 lb. power on the handle to work the pump, which would require 2 men to do the work, unless you obtained extra leverage by wheel work. When the suction- or delivery-pipe is too small, it adds enormously to the power required to work a pump, and the water is then called "wire-drawn." When pumps are required for tar or liquid manure, the suction- and delivery-pipe should be the same size as the pump barrel, to prevent choking.

The operations of plumbing and making joints in pipes will be found fully described and illustrated in 'Spons' Mechanics' Own Book.'

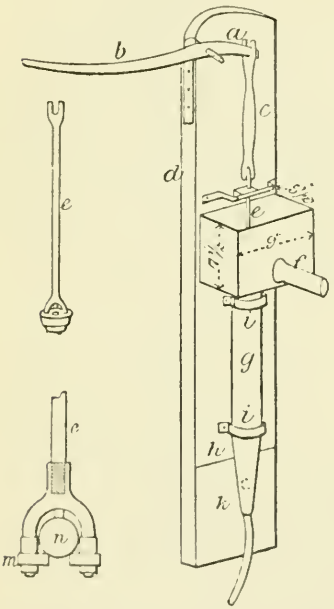
For Acids.—The chief difficulty with acids is their corrosive action on the materials employed in pump construction, necessitating the replacement of the ordinary materials by others less liable to destruction.

A common leaden lift-pump adapted for use with acid which is neither strong nor hot is shown in Fig. 59: *a*, wooden plank, 5 ft. × 11 in. × 2 in.; *b*, iron handle and support; *c*, iron rod; *d*, iron stay; *e*, copper plunger-rod; *f*, leaden box with spout $1\frac{1}{2}$ in. bore; *g*, leaden barrel $2\frac{1}{2}$ in. bore; *h*, iron plate; *i*, iron bands; *k*, leaden ball valve; *l*, leaden supply-pipe $\frac{3}{4}$ in. bore; *m*, rubber packing ring; *n*, leaden ball valve.

Doulton's stoneware force-pumps for acids, bleach liquor, alkalies, vinegar, &c., are shown in Fig. 60. They can be used in connection with stoneware socket piping if required, and the various parts can be had separately in case of breakage. They range from $1\frac{1}{2}$ in. bore, 6 in. stroke, raising 44 gal. per hour, and costing 70*s*., to 6 in. bore, 15 in. stroke, raising 1800 gal. per hour, and costing 175*s*. These pumps are

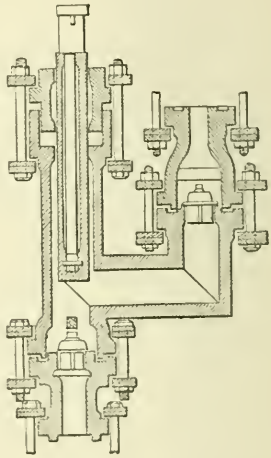
arranged to work by steam power. The plunger is of stoneware, accurately ground to fit the stuffing-gland, this also being ground on the working surfaces. Asbestos is used for packing.

FIG. 59.



The valves, which are of the form usually known as "butterfly valves," are ground accurately into their sittings, the rise being adjusted by the stoneware crossbat, made in the ware above. The jointing of the parts is made by means of a circular groove and fillet fitting into each other, packed with rubber or asbestos, the flange being clipped by two sets of iron semicircles crossing each other, thus forming a continuous ring, through which the bolts and nuts pass as shown in drawing. Stoneware barrels are also carefully made for lift-pumps with rubber buckets. The difficulty of grinding the interior surface of the slider being considerable, this arrangement is not in practical use. The ram is hollow, having an iron rod for attachment passing through the centre, the end being stopped with some acid-proof material, such as sulphur. The iron

FIG. 60.



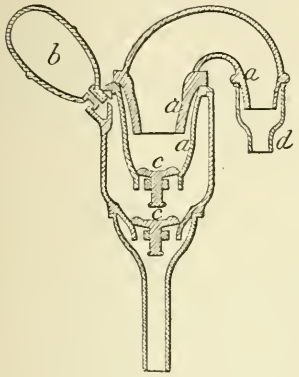
parts are coated with rubber or varnish, as may be necessary for the purpose to which the pump is to be applied.

The application of compressed air to the surface of acid contained in a close vessel with an outlet is much adopted in large works. The vessel containing the acid is usually of cast iron lined with stout lead, and the air pumps are driven by steam. Such apparatus is best obtained from well-known makers, such as R. Daglish & Co., St. Helens, and E. R. & F. Turner, Ipswich. Also W. H. Bailey & Co., Salford, make a special pump for hydrochloric acid.

A very handy contrivance for drawing small quantities of acid from carboys, &c., is known as Nichols' acid pump. This apparatus is securely fixed by a thumb-screw on a pedestal, to be readily adjustable for height. The pedestal is supported on a miniature platform (easily extemporized from an old box), which again is placed on the

carboy. The principle on which the pump is constructed may be seen in Fig. 61. The body or working part of the pump consists of 3 glasses *a* and a

Fig. 61.

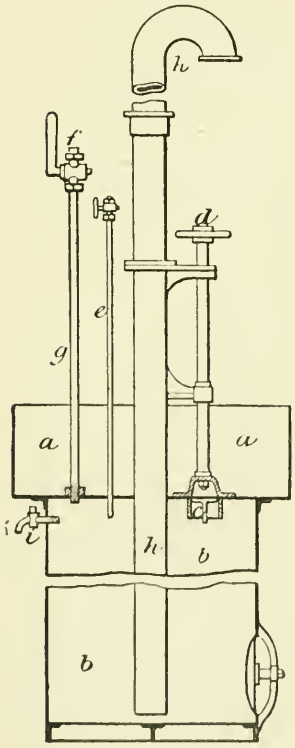


rubber bulb *b*. The glasses are very carefully ground together and secured at the joints by screw couplings, making them perfectly air-tight. The 2 valves *c* are fitted to their places and carefully ground by machinery, which drives the air into the chamber between the glass cups. In use, the rubber bulb is compressed by the hand. The lower valve remains tight, and the air escapes through the upper valve. The hand, now removed from the bulb, allows it to expand, and as a vacuum is created in the chamber, the upper valve closes, and the acid rises through the section tube into the chamber to fill the vacuum. Another compression of the bulb drives the acid up through the upper valve, and the chamber is again filled with acid; as this operation is repeated, the liquid flows from the nozzle *d* of the pump. The relative capacity of the chamber and bulb is so nicely adjusted that the acid never rises high enough in this chamber to enter the bulb. It will be noticed that an air-chamber is formed at every joint by a downward projection of the top piece; this prevents the acid from ever reaching any joint so long as the pump stands erect. A discharge-tube attached to the nozzle of the pump extends to a point just below the bottom of the carboy, so that continuous pumping for a short time will give a siphonic action which can be instantly arrested at any time by the removal of the bulb from its nipple. A metallic bulb may be substituted for the rubber one, giving greater power. By means of a metallic bulb, a large tube may be used on the siphon, which will be capable of emptying a carboy of sulphuric acid in less than 3 minutes. The pump consists of a pump and siphon, which becomes *self-acting* after a few strokes of the bulb. Once set in motion, the acid flows until stopped. Its action is rapid and perfect. The glasses are entirely enveloped in a light cast-iron covering, and the apparatus is light, durable, and perfect in its action. Any quantity of acid can be drawn without the least danger to clothing, person, or floors, and the person using the pump may be entirely inexperienced in such matters.

For Syrups.—The use of force-pumps of ordinary construction for raising cane-juice and syrups is to be condemned on the grounds of their limited capacity, the churning of the liquid and consequent admixture of air, and contamination of the liquid by the grease used in their lubrication. Hence the general adoption of the *monte-jus* ("juice-raiser"), one of whose many forms is illustrated in Fig. 62. The body of it consists of 2 chambers *a b*, separated by a steam-tight diaphragm; the upper chamber *a* receives the syrup to be elevated while the charge in the lower chamber *b* is in course of elevation, and it is made of suitable capacity for that purpose. When the lower chamber *b* is empty, the valve *c* is raised by turning the handle *d*, while the top of the air-pipe *e* is opened. The syrup contained in the upper chamber *a* immediately descends through the valve *a*, any air that may have been imprisoned in the chamber *b* escaping through the air-pipe *e*. This air-pipe extends about 6 in. into the lower chamber *b*, for the

purpose of ascertaining when the chamber is sufficiently full, the escape of air through the pipe *e* being, of course, stopped as soon as the syrup reaches

FIG. 62.



its lower end. The cessation of the whistling noise made by the air rushing through the end of this pipe *e* constitutes the signal for screwing down the valve *c*, to prevent any further flow of syrup into the lower chamber *b*. The air-tap is then closed, and the steam-tap *f* of the steam-pipe *g*, communicating with a steam boiler, is opened, when the empty space between the surface of the syrup and the top of the lower chamber *b* is immediately filled with steam, which at once commences to drive the syrup out through the discharge-pipe *h*. As this pipe is carried down to within a short distance of the bottom of the *monte-jus*, nearly the whole of the contained syrup is forced out of the lower chamber *b*. As soon as any indications of steam appear at the mouth of the discharge-pipe, the steam-tap *f* is shut, and the valve *c* and air-tap *e* are opened to let in a fresh charge.

It will thus be seen that the action of the *monte-jus* is exceedingly simple, only one precaution being necessary, viz. to shut the valve *c*, through which the syrup is running, in time. If the syrup be allowed to reach the top plate of the chamber *b*, the steam, when let in through the pipe *g*, will mix with and boil the syrup, but will not elevate it; considerable difficulty and delay sometimes arise from this circumstance. As a precaution against carelessness, an overflow tap *i* should be fitted to the shell of *b*, a few inches below the top, so that the superabundant syrup might be drawn off. In the case of cane-juice, as it comes from the *monte-jus*, it is said to be sufficiently warmed to retard fermentation on its way to the clarifiers.

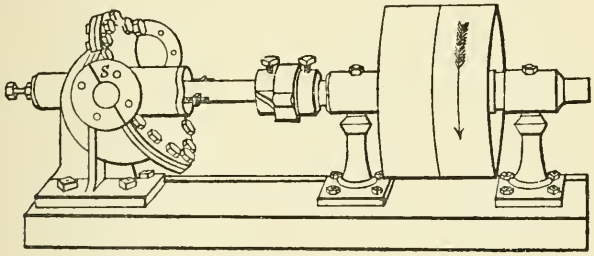
While this instrument remains by far the most generally adopted means of raising juices and syrups, its superiority has not been unchallenged. It has been objected that its interior is not readily accessible, and that it is therefore difficult to keep clean, whereby fermentation may be caused in juices by the presence of accumulated dirt within the *monte-jus*. It is also urged that the liquor is diluted by the admixture of condensed steam.

Hence, in many cases, the *monte-jus* has been replaced by centrifugal pumps. In favour of these, it is advanced that there are no valves or other mechanism to become a refuge for dirt; no air or steam is forced into the liquor; and, with properly adjusted arms, the juice or syrup is raised in a solid column

without churning. Many statements, however, point to the fact that the churning is often seriously worse than with the *monte-jus*. In the best central sugar factories, steam in the *monte-jus* is replaced by air under a pressure of 60 lb. per sq. in., thus obviating most of the drawbacks that have been complained of.

For Soap and Lye.—Pumps of several kinds are employed in soap-works, for removing spent lye and soap from the coppers. For small pans, a simple hand

FIG. 63.



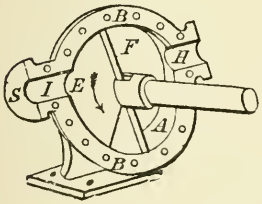


FIG. 64.

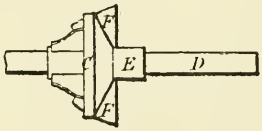


FIG. 65.

suction-pump answers; for larger ones, a single- or double-acting lift- or force-pump may be placed inside the copper, and worked by hand, or by an eccentric on a shaft. In large factories, some form of centrifugal pump is found useful. Their great advantages are the absence of valves and easily deranged working parts, and the large amount of work they can do in a short time. The pumps made by J. & H. Gwynne, 89 Cannon Street, London, are in most favour in England; the form usually employed in America is that bearing the name of Hersey Bros., Boston, Mass., which is represented in Figs. 63, 64, 65. The pumps require to be connected with pipes having swing joints to permit their being raised and lowered at will. To avoid the pipe system becoming choked by soap congealing in it, a steam-pipe should be inserted at one end, to warm the pipes and pump previous to use, and to "blow out" all their contents at the end of the operation. In the illustrations, S is the suction-pipe; H, delivery-pipe; F, blades set upon a cone (the rotation of which in the closed case produces the pumping), which is kept in its place by adjustable set screws. This pump will transfer to any desired part of the factory, lye, melted fat, finished soap (if not too stiff), "nigre," and soft curd. The diameter of the pump is 10 in., of its outlet 2½ in.; when making 120 rev. a minute, it will pump 6000 gal. an

hour, its contents being twice emptied in each revolution.

Siphons.—Where fluids have to be transferred from an upper to a lower level, passing on the way over an obstacle of greater height than the upper vessel, a siphon may conveniently replace a pump, as, once the stream is started, it will continue flowing indefinitely until the level of the liquid in the supply vessel becomes so low as to admit air into the siphon.

In its simplest form, the siphon is merely a pipe bent into a U shape, with one leg longer than the other; the shorter leg is placed in the liquid which is to be drawn off. To start the siphon, it is necessary to empty it of air and fill it with water or the fluid to be siphoned; this is best accomplished by turning it end upmost and pouring the liquid in at the longer leg till it overflows, the thumb being meanwhile held over the orifice in the shorter leg. Both ends are stopped in this way while inverting the siphon into the vessel to be drawn from, and care must be taken not to remove the thumb from the mouth of the longer leg till after the shorter leg is free to draw its supply.

Figs. 66, 67 show handy glass siphons adapted for small operations, the former

FIG. 66.

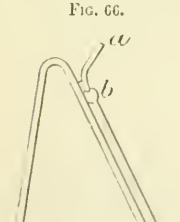
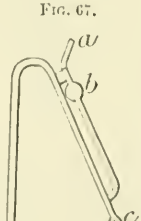
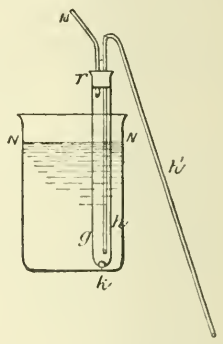


FIG. 67.



being without, the latter with, a stop-cock c for regulating the flow. The current is started in these by applying the mouth to the end a of the tube, and employing it as an air-pump to exhaust the air till the fluid rises into the bulb b. With harmless liquids, a simple bent glass tube may suffice as a siphon; but suction with the mouth at the end of the longer arm is somewhat inconvenient. The arrangement shown in Fig. 68 is simple, and

FIG. 68.



presents certain advantages:—A glass tube g, $\frac{3}{4}$ in. wide, and 12–16 in. long, contracted at the lower end, has, at its upper end, a cork stopper, in which the mouthpiece M and the siphon $h\,h'$ are fixed air-tight. The shorter arm h of the siphon reaches nearly to the bottom of the tube, and limits the play of a glass ball k, which acts as a valve. The diameter of the ball is about $\frac{1}{2}$ in., that of the siphon $\frac{1}{4}$ in. The instrument thus arranged, being dipped into the vessel to be discharged, the tubes g and h become filled with liquid to the surface N N. Instead now of sucking, as with the common siphon, one blows into the mouthpiece M; and in consequence of the compression of air, the lower opening is shut by the ball k, while the liquid rises in h, and begins to flow through h' in the usual way. If the vessel to be emptied is not full, or the column of liquid is a small one, it is necessary, before blowing into the mouthpiece, to suck it slightly, in order to obtain a larger volume of the liquid in g; as one condition for the right action of the instrument is that

$h\,h'$ should be filled before the column of liquid in g sinks to the mouth of the siphon at k, when one blows through M.

Fig. 69 shows a method of constructing a siphon suited for drawing off large quantities of hot or corrosive liquids (the dimensions given being adapted to sulphuric acid boiling pans). In the figure, n is a leaden siphon, $1\frac{1}{2}$ in. bore, through which acid is to be drawn from the pan, that lies hidden in brickwork behind the stay bar f; o is a leaden cup, 18 in. deep, 4 in. diameter, attached to a weight by a chain passing over a pulley. This cup is filled with acid; the siphon is also filled with acid, and set with one leg in the pan and the other in the cup. When the cup is lowered, the acid flows through the siphon and overflows the cup, running into p, a leaden box, 3 ft. 3 in. deep, and 9 in. diameter, whence it flows through q, a leaden pipe leading to cooler or retorts. When the cup is raised so much that the top of it is above the level of the acid in the pan, the acid ceases to flow. In the drawing, the cup is shown raised to its highest, the top being a little above the level of the top of the pan, so that were the pan quite full of acid, none would run out until the cup was lowered. The cup keeps the siphon constantly set; but if all the acid were drawn from the pan, air would enter the pan leg of the siphon, and it would become unset. Similar siphons are used for drawing acid out of the chambers.

FIG. 69.

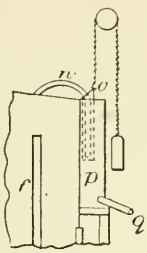
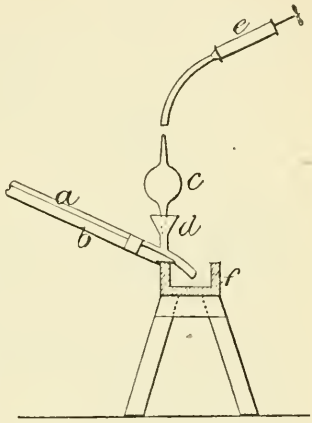


Fig. 70 shows a portion of another form of siphon, generally used for drawing off sulphuric acid from the retorts in which it is concentrated, but equally useful for many other purposes. The siphon a is formed of a piece of $\frac{1}{2}$-in. bore leaden pipe, bound to a small strip of wood b; c is a glass globe with 2 tapering tubes, the end of one tube being inserted into a leaden funnel d, in which c is hermetically sealed by a mixture of melted brimstone thickened with a little sand; e, an exhausting syringe, to the mouth of which is attached a short piece of

FIG. 70.

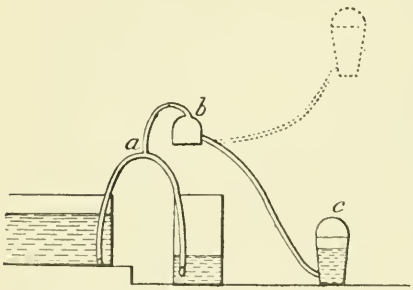


rubber tubing. To set the siphon, one person takes a small piece of sheet rubber, say $\frac{1}{8}$ in. thick, and holds it tightly against the mouth of the siphon, to stop the passage of air, whilst a second person takes the syringe and slips the end of its flexible tubing over the end of the upper tube of the glass globe. On working the syringe a few strokes, the air becomes exhausted from the siphon, causing the acid to flow through it, and commence to fill the glass globe. The syringe is then removed, and the piece of rubber is quickly withdrawn from the mouth of the siphon; the acid continues to flow until the retort is nearly empty. A wooden trough f lined with lead (shown in section), catches the acid from the siphon, and leads it to the cooler.

A siphon setting apparatus is shown in Fig. 71; a is the siphon; b, a closed leaden vessel; c, an open vessel or bucket. A small metallic pipe connects the top of the siphon with the top of the vessel b, and a rubber tube connects

the bottom of *b* with the bottom of *c*. To set the siphon (both legs of which must be standing in liquid), fill the bucket with water, raise it above *b*, and hold it there till all the water has run

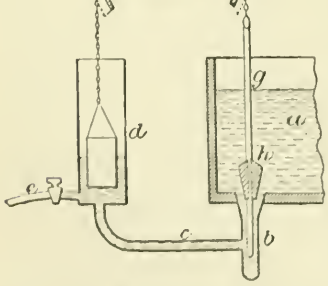
FIG. 71.



into the vessel *b*. Then stand the bucket down, and the water will flow back into it; the vacuum thereby created in *b* will exhaust the air from the siphon, and set it running.

To obtain a uniform flow of acid or other liquid under varying degrees of pressure the apparatus shown in Fig. 72

FIG. 72.



is used. *a* is a cistern containing acid or other liquid; *b*, a well in the cistern having a conical mouth; *c*, a pipe connecting the well and cistern with the cylindrical vessel *d*, which must be the same height as *a*; *e*, a delivery-pipe fitted with a tap; *f*, a lever working on a central pivot. One end of the lever is attached by a chain to a leaden bucket which hangs in the vessel *d*, and the other end is attached by a short chain to the rod *g* (which is of iron cased in lead), having cast on it the conical plug *h*, which must fit accurately the contracting mouth of the well *b*. The extension of the rod below the plug serves to keep the latter in its seat. The tap in the pipe *e* being opened, the greater the pressure of acid in *a*, the higher it will rise in *d*, elevating the bucket and depressing the plug *h*, which will check the flow. Thus at whatever height and consequent pressure the liquid in the cistern may be, the pressure or flow from the delivery-pipe will be uniform.

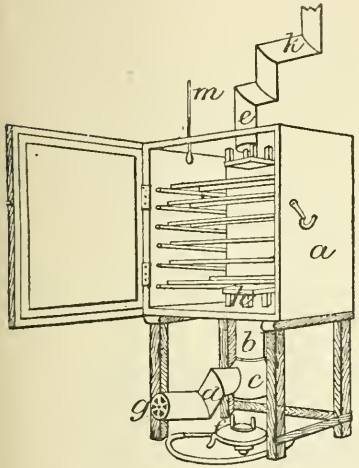
DESICCATING. — There are many industries and operations where the removal of excess moisture from solid bodies is an important feature. Convenient means of effecting this object will now be described. The apparatus employed may be divided into two classes, air-ovens and water-ovens, according as heated and dried air or hot water is the active medium.

Air-ovens.—The ordinary steam or hot-air chambers for laboratory use, although meeting the most of the requirements for which they are designed, have the disadvantage of being more adapted for experimental than manufacturing purposes. The want of a cheap and convenient apparatus induced Maben to bring under notice a design (Fig. 73) due to Hislop, one of his apprentices, who intended it for drying photographic gelatine plates; but, by slight modifications of the interior, it is perfectly adapted for the purposes of the laboratory.

The chamber consists of a strong wooden box *a*, 18 in. high by 18 in. wide, and 14 in. deep. To the front a door is attached, hinged in this instance, but a vertical sliding movement would

be more convenient. To 2 sides of the box are fixed wooden supports, which serve to receive teak spars for supporting drying trays or evaporating dishes.

FIG. 73.



The bottom of the box has a perforation of 3 in. diameter into which a zinc cylinder *b* is securely fitted, and to this is soldered the upper end of a copper cone *c* with a flat bottom, while into this latter a bent tube *d* 2½ in. diameter, and 9 in. total length, is securely inserted in the manner shown. A corresponding perforation is made in the top for receiving a tube to answer the purposes of a chimney.

Using a Bunsen burner or a spirit lamp as the source of heat, the flame is directed to the bottom of the cone *c* with the result that the heated air ascends into the chamber, being diffused by means of a dispersion board *h* about 4 in. square, which is placed over the orifice. At the end of the tube *d* is fitted a "hit-and-miss" regulator *g*, which consists of a series of triangle-shaped holes, with a revolving disc behind, so that the size of the apertures can be increased or diminished, thus enabling the amount of air entering to be under partial control. The highest temperature to which the air in the chamber has been raised is 180° F. (82° C.) which is sufficiently high for most operations. If a uniform temperature of say 100° F. (38° C.) be required, the admission of air must be regulated accordingly by means of the regulator *g*, accuracy being ensured by the insertion of a thermometer *m* into a perforated cork fitted into a ½-in. aperture on the top of the chamber. By this means, there is no difficulty in keeping within 2½° less or more of the desired temperature.

If a rapid current of warm air is desired, this can be had by placing an angular tube *k* on the top of the chimney *e*; by heating the angle of the tube, a draught is quickly created.

It is desirable in some cases to filter the admitted air; this can be done by stretching a piece of lint or other suitable material between the regulator *g* and the tube *d*, by which means dust particles are effectually excluded.

The metallic parts of the apparatus being made to screw off and on, they can be detached at will, so that we can thus have a series of wooden chambers suited to different purposes. In this instance, the chamber being intended for drying gelatine plates, it was of course constructed so that the light would be effectually shut out, but it is obvious that a small glass window would add greatly to its value for most other purposes. The advantages of this chamber are its simplicity, its perfect security against overheating, and its small cost,—it can be made for a few shillings. It is light and easily handled and is always ready for work, a current of pure hot air being obtained in a very few minutes after the application of the Bunsen flame. It is specially adaptable in the preparation of granular and scale compounds, for drying precipitates, hardening pills previous to coating, and in other operations requiring a current of hot air.

Another writer describes his drying-closet as being made of teak 1 in. thick, with light-tight door in front; the ends

project beyond the bottom to form legs; the top and bottom are both double (4 in. apart), and the air enters through a slit 3 in. wide, and reaching right across the box. This slit is at one end, and the air has then to pass along the double bottom to the other end, where it gets into the box through a similar slit, thus keeping out the light; and it gets out at top in a similar way. Over the exit at top is fitted a tin or copper chimney 3 ft. high, in which burns a Silber lamp, giving a good draught, and drawing a large quantity of air through. Inside the box are brackets (each having a levelling screw through it, with the point upwards), projecting from the ends, on which are laid plate-glass shelves cut the width of the box, but 3 in. shorter, so that when the shelves are in place, if one is pushed close to the right end of the box and the next to the left, and so on, the air has to pass backwards and forwards over the plates. His box has 3 shelves, 13 in. wide and 32 in. long, and will dry 6 photographic plates 15 in. by 12 in., or, of course, anything less that will lie in the same space. Some have an arrangement for drying and warming the air before it enters the box; but this sometimes induces blisters and frilling. Shelves should be far enough apart to get the hand in easily, say 6 in. Fig. 74 shows a sectional view of another form of photographic drying-box. *a* are shelves on which to put plates. In the drawer *b* are placed some lumps of calcium chloride. This absorbs moisture very rapidly, and the air in passing through it is thoroughly dried. In the flue *d* is a small gas-burner, and below is a light trap *c*, made of tin. The gas-jet is for the purpose of causing an extra current of air to pass over the plates. It is better to confine the plates as much as possible to the 2 middle shelves, as there they are sure to be safe. At *e* is a sketch showing how the door of the box should be rebated into the side.

FIG. 74.

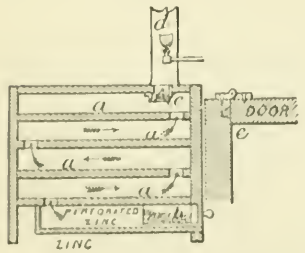
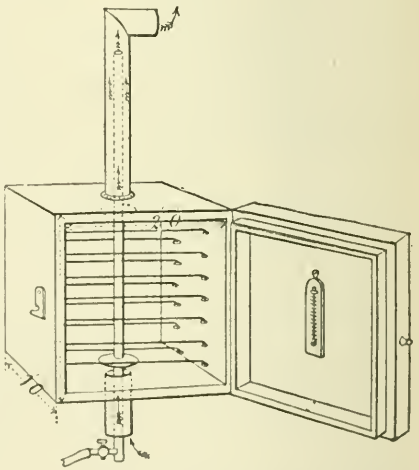


FIG. 75.

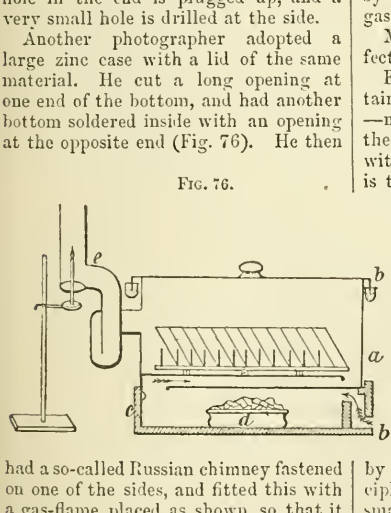


England's drying closet, Fig. 75, is simply a light-proof box with wires stretched across the interior to support the articles to be dried, e. g. photographic plates. Through the centre runs a 1-in. gas-pipe, open at both ends, with a small gas-jet burning inside it at the lower end. At the top and bottom of the box 2 draught holes are cut, to which a tin tubing of about 3 in. diameter is attached. The gas-tube gets warmed with a very small jet of gas burning in it, a mere pin-hole being

sufficient exit for the gas. This warms the air in contact with the tin tube, and also slightly the air inside the cupboard. The consequence is, that a current of slightly warm air is set up, and circulates amongst the plates while supported on the wires, and the drying of the films takes place rapidly. Some 5–6 hours is a sufficient time in which to dry the plates, whilst without the gas-jet it would take 24 hours or more. In the inside of the cupboard, and near the top and bottom, are placed 2 cardboard discs to stop the possibility of any stray light entering, and as the whole affair is placed in the dark room, the chances of any such access even without it would be small. Inside the cupboard door is a thermometer, and the jet is regulated so that a temperature of about 70° F. is indicated—80° would do no harm to the plates; beyond that temperature, it might not be safe to go. The small gas-jet used is the same as may be seen in tobacconists' shops; the hole in the end is plugged up, and a very small hole is drilled at the side.

Another photographer adopted a large zinc case with a lid of the same material. He cut a long opening at one end of the bottom, and had another bottom soldered inside with an opening at the opposite end (Fig. 76). He then

FIG. 76.



had a so-called Russian chimney fastened on one of the sides, and fitted this with a gas-flame placed as shown, so that it might produce the necessary current of air. To make the cover fit air- and light-tight was rather more difficult. This, however, he managed in the following manner. He had a rim soldered all round in the shape of a gutter, the edge of the lid sinking into the bottom of the gutter, and then filled the latter with small shot, and thus obtained a most perfect closure. This box has been in use ever since, and, with the addition of a wooden tray, and of an iron vessel full of calcium chloride, has done very good service. In the figure, *a* is the zinc case; *b*, gutter filled with shot; *c*, wooden tray; *d*, calcium chloride vessel; *e*, Russian chimney.

The usual forms of hot-air baths used in laboratories are, almost without exception, affected by drawbacks, particularly the following:

1. Either the temperature in the upper and lower parts is different;

2, or the temperature differs with the duration of heating;

3, or it can only be raised to a moderate degree;

4, or, finally, it can be kept up only by a relatively large consumption of gas.

Meyer proposes to remove these defects in the following manner:

Equality of temperature may be attained by applying the heat at the side —never below—and by taking care that the flame never comes in actual contact with the metal. The space to be heated is to be surrounded with the hot products of combustion of the flame mixed only with the smallest possible excess of air, in such a manner that a triple layer of heated gases, proceeding from without inward, surrounds the inner mantle. Besides, the outer, or hottest layer, must be protected from too rapid cooling by applying a suitable coating of bad conductibility for heat.

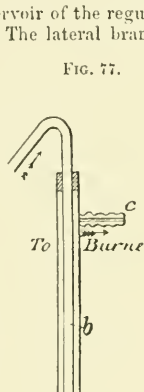
Equality of temperature for any length of time may be best attained by a regulator constructed on the principle of Andrea's, which contains, in a small, confined space a small quantity of a liquid having a boiling-point a trifle below the degree of temperature to be maintained. The author prefers

the modified form suggested by Kemp, and improved by Bunsen, which is wholly constructed of glass except the lower end of the gas-tube, this being made of perforated sheet-platinum.

In order to fill it, the gas-tube *a*, Fig. 78, is temporarily replaced by a tube *b* drawn out at both ends and reaching down into the reservoir of the regulator (top of Fig. 78). The lateral branch *c*

FIG. 78.

FIG. 77.



is now connected with the vacuum pump, the whole inverted (as in Fig. 78), and the contracted end dipped, first for a moment into the liquid to be used as regulator, and then into mercury, until the chamber is almost, but not quite, full. The apparatus is now turned over, a little more mercury poured in, and the gas-tube *c* is inserted. When using the apparatus, the gas-tube is first drawn upwards, and, when the proper temperature has been nearly reached, pushed down into the mercury until the supply of gas is reduced to a minimum. By cautious adjustment, it is easy to find the position at which the tension of the vapour developed in the tube raises the column of mercury sufficiently to just close the orifice of the tube *c* at the proper temperature. As the air-bath cools off very slowly, but heats up rapidly, it is of advantage to adjust the regulator to a slightly lower temperature than actually required.

It is best to have a series of such regulators, charged with substances, the boiling-points of which are about 30° C. apart, and to keep them in a proper receptacle for use. Suitable substances are, for *water-baths:* ethyl chloride, ether, carbon disulphide, mixtures of ether and alcohol, pure alcohol, benzol; for *air-baths:* water, toluol, xylol or amylic alcohol, cymol or oil of turpentine, aniline or phenol, naphthalin, diphenyl or diphenylmethane, diphenylamine, and perhaps also anthracene. It is not at all necessary to use these in a pure state, particularly those which are solid at ordinary temperature, since they melt more easily when impure. Only very little of solid substances should be introduced, for the excess distils off, and may clog up the gas-tube.

Figs. 79, 80, and 81 show the air-bath as usually employed by the author. It consists of 4 concentric walls of sheet copper, 2 of which are attached to the upper plate, and the others to the bottom plate.

Fig. 79 is arranged for a drying chamber: Fig. 80 for the distillation of substances which easily decompose when coming in contact with (over) heated glass; Fig. 81 for the dry distillation of substances which should not be heated beyond a certain point (f. i., citric acid in the preparation of aconitic acid, &c.).

The innermost cylinder* surrounds the space *a* to be heated, which is closed from below by a double bottom *b*, fastened by a bayonet-clamp. The upper cover, also double (the 2 walls being kept parallel by inner supports, of which one is shown at *h*), has 2 tubulures, one (*l*) for the insertion of a thermometer, another (*i*) for the regulator, and another

* The air-chambers illustrated above are not square, but *round*. The illustrations represent a vertical section through the centre.

for the escape of the heated vapours. To this cover the 2 cylinders *d* and *f* are attached, while *c* and *c* are soldered to the bottom piece, which is also provided

FIG. 79.

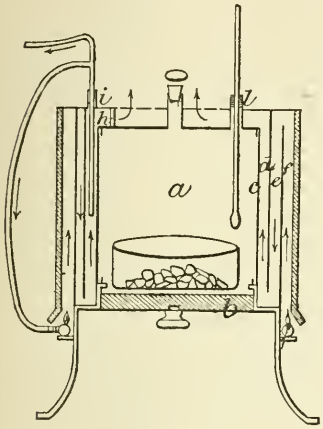
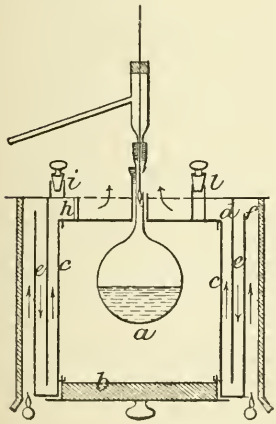
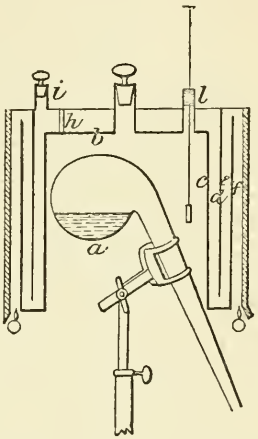


FIG. 80.



with 3 legs. The heating is done by a brass ring attached to the legs, with a supply of gas controlled by the regulator *i*. The ring has holes of 2–3 millimeters bore in intervals of 3 centimeters. The little flames thus produced burn quietly, and may be easily regulated. With the same amount of

FIG. 81.

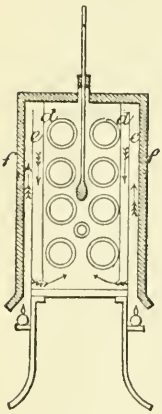


gas which is furnished by a gas-cock supplying an ordinary Bunsen's burner, the space in *a* (= about 5 litres) may readily be heated to 300° C. and over, even when it is not closed below. But in order to obtain this result, the intervals between the several cylinders, in which the products of combustion circulate, must not exceed 10 millimeters. Besides, the outer cylinder *f* must be protected with a non-radiating cover. The best, for this purpose, is a layer of asbestos (in sheet), to be applied so as to leave a little space between it and cylinder *f*, which space is to be filled out with siliceous earth ("kieselguhr") or mineral wool.

If tubes are to be heated, the modification shown in Fig. 82 may be used. It is also here of importance that the channels through which the warm air circulates are very narrow, scarcely 1 *cm.* apart. The 8 iron tubes pass through the narrow walls, which latter are not double, but covered with little flaps hinging upwards (one correspond-

ing to each tube), as closely as possible fitting to the surface of the outer cylinder, but remaining slightly distant from the ends of the tubes. In case a glass tube (inserted in one of the iron tubes, for being heated) should explode, its fragments are caught by the loosely hanging flaps. Between the iron tubes, a Babo's regulator may be inserted.

FIG. 82.



For special uses the above forms of air-baths may be still further modified. It is, however, of importance to remember that the heated gases should surround the space to be heated in a triple layer; that the hottest layer should be near the outside, and that the intervals between the walls should admit as little excess of air as possible. The gases escaping above must have the property of extinguishing a glowing splinter of wood.

Edmund Bühler, of Tübingen, furnishes air-baths of the above-described construction.

A much enlarged form of the hot-air closet is widely adopted in curing agricultural produce, such as fruits, tea, &c.

Everywhere in Tennessee, North Carolina, and Georgia, one may see at the farmsteads rows of boards tilted up to the sun and covered with sliced fruit. Sometimes it is spread between sheets of muslin to keep away the insects, and to give the fruit a finer colour. These small lots of fruit are collected by the country storekeepers, and thus find their way to the great cities and a market. The first improvement made in drying fruit was tried in the North, and consisted in covering the fruit with glass. The hot-bed sash idle in the barn found a new duty. Wooden boxes or frames made to fit the sash were prepared and set upon legs to raise them above ground. Holes were cut at the front near the bottom, and at the back near the top, to secure a current of air through the frame; within these glass-roofed frames the fruit was spread on trays in the full sun-light. The glass kept out rain, birds, and insects, and the fruit dried more quickly and with less labour than in the old way, and with a decided improvement in its appearance. Experiments were also made with stoves. The cooking stove dried the fruit more quickly than the sun, but it was wanted for other purposes. The next step was to erect drying closets. A small enclosed place or closet of any convenient shape or size was put up in the farm-house or shed, and in this was set a small stove. The sides of the closet were protected from the fire by brick-work, and above the stove were ranged shelves for the fruit; inlets for the fresh air were made at the bottom, and at the top ventilators were provided for the escape of the heated air and vapour. Such appliances answered a very good purpose, and are often used to save the surplus fruit of a small farm for domestic use or for sale. Besides these domestic appliances there is now in use a very good iron stove or drying machine, costing about 70 dollars, and serving to dry all kinds of fruit in a much better manner than the wooden closets, which are liable to take fire. This stove is portable, and may be used out of doors or in a building, as is most convenient. A fire is kept up in the fire-box at the base, and above it are movable shelves for apples, peaches, berries, corn, grapes, or other fruits or vegetables. A constant stream of hot air passes through the apparatus, sweeping across the trays of fruit and quickly extracting all their moisture. The smoke-flue from the fire passes through the escape for the hot air, and materially assists the movement of the air. Driers of this form are largely used in the peach districts of the East and the grape-growing country of the Pacific coasts. They are easily managed, and will dry as much

fruit in a day as a family can peel and slice in that time.

At one American establishment, apples are pared, cored, and sliced at once by hand machinery. The slices are then spread on galvanised screens and placed in the evaporator, a chamber running from the top of a large furnace in the basement upward, out through the roof of a 3-story building. The current of heated air is kept as near as possible to 240° F. (116° C.). The screens of fruit rest on endless chains that move upwards at intervals of 3 to 5 minutes, when a fresh screen is put in below and one is taken off at the third story completed. The dried or evaporated produce is then packed in pasteboard boxes holding 1–5 lb., and these in turn are packed in cases of 200 lb. each.

A bushel of apples makes about 5 lb. of the dried fruit; and the process of evaporation is so rapid that the fruit loses none of its freshness and flavour. In some of the factories the cores and peelings are converted into vinegar; in others into apple jelly, out of which every variety of fruit jelly is made by the addition of flavouring extracts. Sweet corn, potatoes, and other vegetables have been successfully preserved by this process.

In properly evaporated fruit there is no loss of pleasant or valuable properties, but an actual increase of fruit sugar, from the fact that evaporation is essentially a ripening process, the development of sugar ranging from 10 to 25 per cent. in different fruits, as determined by chemical analysis. By the process of evaporation, properly conducted, in a few hours the juices are quickly matured, the maximum development of sugar is secured, and water pure and simple is evaporated, the change being analogous to the transition of the grape to the sweeter raisin, or the acid green apple to ripeness, with corresponding delicacy. The cell structure remains unbroken, and the articles, when placed in the rejuvenating bath of fresh water, return to their original form, colour, and consistency.

In evaporating cut fruits, such as apples, pears, and peaches, the correct method is to subject them to currents of dry heated air, so as to dry the cut surfaces quickly, preventing discoloration, forming an artificial skin or covering, and hermetically sealing the cells containing acid and starch, which yield glucose or fruit sugar. This principle is demonstrated in Nature's laboratory, in the curing of the raisin, fig, and date, which are dried in their natural skins —a process not applicable to cut fruits —in a tropical climate, during the rainless season, by natural, dry, hot air, in the sun; though a crude and slow process, the development of glucose or grape sugar is almost perfect.

A practical, economical, and inexpensive fruit drier is made by the American Manufacturing Company. In this evaporator separate currents of dry, heated air, automatically created, pass underneath and diagonally through the trays and then off and over them, carrying the moisture out of the evaporator, without coming in contact with the trays of fruit previously entered, and already in an advanced stage of completion. The greatest heat is concentrated upon each tray when it first enters the machine; and each tray subsequently entered pushes the previous one forward into a lower temperature. This operation is continued throughout, being rendered perfectly practicable by an inclined, divided evaporating trunk.

It is stated that about a third of the tea produced on Indian estates is cured in Davidson's so-called "sirocco" drying-closets. These are made in 2 forms, one having the fire-place adapted for wood, coal, bamboo, ekur grass, or similar fuel, the other suited only for a smokeless combustible, such as coke or charcoal. In the first-named from the furnace of the air-heater is lined with fireclay tiles, and is so arranged that when, from accidental breakage, any of the tiles require changing, this can be easily done through the fire-door, without having to take down any part of the apparatus. All the other parts of the air-heater are very durable, and not liable to breakage.

An improvement has been applied in

the construction of the top of the air-chimney, which has completely obviated the necessity for any rain hood or cover (all of which had a harmful effect on the draught). The base of the air-chimney sits on an annular collar, so constructed that it collects and discharges, wherever required, any water which, on rainy days, may come down the chimney, either from a bad joint where it passes through the tea-house roof, or from condensation of vapour inside the chimney. This water collar is applicable to already existing "siroccos."

The trays are made from a special wood, which, after having carefully tested many qualities, has been selected as being the best suited to stand, without warping or twisting, the very high temperatures to which they are subjected; they are strongly put together, being brass-bound at the 4 corners, and the wooden battens screwed together with bolts and nuts, by which they can, if necessary, be tightened up from time to time.

With the exception of the trays, the closet is entirely constructed of iron, and can be readily put together and worked, even by an inexperienced person. It requires no motive power to create the draught, which is self-acting. When erected, it occupies a floor space of about 5 ft. by 4 ft., and is 10 ft. in height from base to where the air-chimney joins.

This apparatus is capable of drying 20–25 *maunds* (1 *maund* = 80 lb.) of green leaf per day of 10 hours, with 6–8 *maunds* of dry wood, or $2\frac{1}{2}$–$3\frac{1}{2}$ *maunds* of coal fuel.

The second form differs only in having a brick-built fire-place.

With either form there should be a wooden platform for the man working it to stand upon, and a table for the trays to be rested on when the material is being spread upon them. One end of this platform should project underneath the apron tray upon the front of the drying-box, and should nearly touch the side of the air-heater casing. The dimensions of this table and platform should be as follows:—

Table, length, 8 ft.; width, 4 ft.; height, 6 ft. Platform, length, 8 ft.; width, 3 ft. 8 in.; height, 3 ft. 6 in. Stair to platform, with 2 steps, length, 8 ft.; width of each step, 1 ft.; height of each step, 1 ft. 2 in.

Of course the apparatus might be sunk into the ground sufficiently to avoid having to use a platform at all; but in that case an open space of at least 1 ft. in width would have to be left on each side for admitting the cold air to the air-heater, and a stoke-hole opposite the fire would be necessary, as well as a similar place on the other side to get at the door for cleaning the chimney. A large excavation like this, however, is obstructive and generally objectionable in the floor of a tea house, and the makers prefer and recommend instead of it the use of the platform and high table, with the apparatus set on ground level, as hereinafter described. Should the apparatus be sunk into the ground, the sides of the excavation will require walls to prevent the earth from falling in; but if it be placed upon the ground level, no brickwork will be required.

It has occasionally been observed that the working of driers is more or less influenced by their situation in the tea house, and that it is desirable, when practicable, to have the apparatus placed on the opposite side of the house to the prevailing winds—i. e. as the winds prevail from S.W. it is well to have the driers situated on the N.E. side of the tea house, otherwise there may be a tendency to a down draught upon the chimney, which would materially affect the outturn of work; whereas, if placed on the opposite side, the tendency is just reversed, and the draught up through the apparatus is increased by the wind pressure.

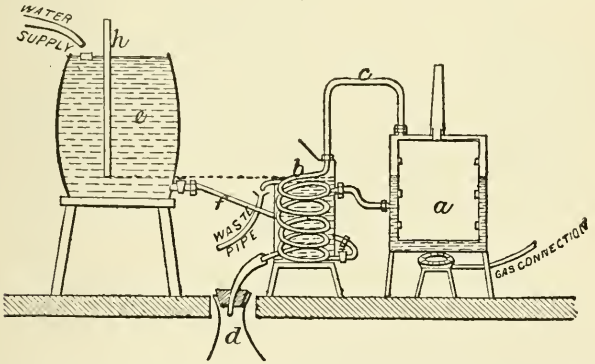
Air-holes should always be kept open on the wind side (S.W.) of the house to admit the outer air freely, because each drier (when properly working) is continuously drawing away about 30,000 cub. ft. of air per hour from the house, and if the apparatus has to overcome any friction or resistance in obtaining this air supply, the outturn of work will be proportionally reduced.

It may be here stated as a general rule that (provided the proper working temperature of the drier is maintained) the better the draught of the apparatus, the larger will be the outturn of work; and, consequently, everything which tends to accelerate this draught should be observed and taken advantage of.

Further details respecting this apparatus may be obtained of the makers, Davidson & Co., Queensbridge Street, Belfast. It is obviously adapted to the drying of many other vegetable products.

Water-ovens. — The accompanying sketch (Fig. 83) of a combined steam-oven and distilled water apparatus, so arranged as to be left to itself for a long period of time without the risk of the boiler going dry, may perhaps be of interest to many, and a few words only are necessary to describe its working. The steam oven *a* is of the ordinary construction, but is fitted at the side with a tube connecting it with the condenser *b*. Heat is applied to *a* by means of a radial burner, connected with the gas supply by metallic tubing; the steam generated circulates around the drying chamber, escapes through the copper tube *c*, thence through block-tin worm, and falls as distilled water in the receiver *d*. The cistern *e*, fitted with a Mariotte's tube, holds cold water, which falls through the tube *f*, enters the condenser, where it rises slowly, absorbing heat from the condensing-worm, until it reaches the tube leading to the boiler at a high temperature. For a cistern, an 18-gal. ale cask, supported on a stool, has been found to answer admirably, having the advantage of holding sufficient water on the top to secure the 2 corks being air-tight. By a suitable adjustment of the Mariotte's tube *h*, the rate of flow of the water can be so regulated that the level of the water in the condenser is constant, or, if desired, allowed to drop slowly into the waste pipe, while the water evaporated from *a* is renewed by water already near boiling. In practice it has been found necessary to allow the water to waste at the rate of about 2 drops per minute, the 18 gal. lasting for over 72 hours, during which time 10–11 gal. of distilled water are collected. When this apparatus was first fitted up in the laboratory, it was intended to have connected the condenser directly with the town water supply, but as the water-works authorities would sanction no such connection, we had recourse to the cistern, with the satisfactory result that we are in this respect quite independent of the caprice of the water-works turncock. The several connections are made by

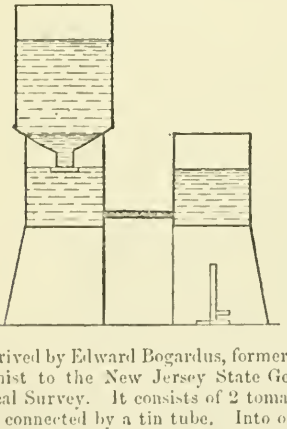
Fig. 83.



union joints, to allow the apparatus to be taken to pieces and the boiler freed from scale. The whole apparatus may be supported upon a strong shelf, which should be protected from the heat of the burner by means of slates or asbestos millboard. With this arrangement, bulky precipitates may be allowed to remain in the steam-oven all night and found ready for further treatment next morning. (*Chemical News.*)

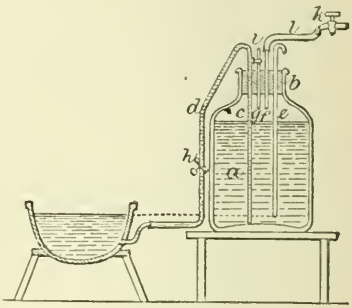
Prof. Peter T. Austen, of the Chemical Laboratory of Rutgers' College (N. J.), says: We have used for a number of years in this laboratory, a form of constant water-bath, Fig. 84, which was

FIG. 84.



contrived by Edward Bogardus, formerly chemist to the New Jersey State Geological Survey. It consists of 2 tomato cans connected by a tin tube. Into one of the cans a bottle of water is inserted (e. g. a 5-lb. acid bottle), the other can makes the bath. This bath can be left overnight without risk, and a number of baths can be similarly fed by connecting them by means of a rubber tube with a single reservoir, made of a fruit can with a number of holes punched near its bottom, perforated corks carrying short pieces of glass tubing being fitted to the holes. A similar contrivance can be used to make the connection with the can serving as the water-bath. Such vents in the reservoir as are not in use can be closed by means of short bits of rubber tubing and pinch-cocks. Fig. 85 illustrates a water-bath constructed on the principle of Mariotte's flask. *a* serves as reservoir of water and is closed air-tight by the perforated, rubber stopper *b*.

FIG. 85.

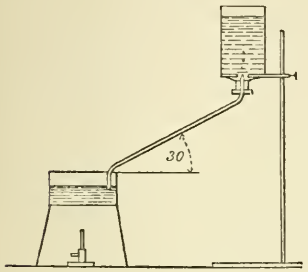


Through the latter pass 4 glass tubes, one of which, *c*, acts as a siphon, in connection with the rubber tube *d*, to supply water to the bath. The level in the latter is regulated by the depth to which the lower end of tube *e* reaches. The other 2 tubes, *f* and *g*, are closed while the apparatus is working, and are only used for filling it. When this is necessary, the pinch-cock at *h* is made to compress the rubber tube, the stopper *i* of the tube *g* is opened, and water is admitted to the flask through *k l*. If it is inconvenient or impracticable to keep the short rubber pipe *l* constantly connected with a water faucet, it may, when the flask is filled, be detached, and the open end pushed upon the glass tube *g*, in which case it is not necessary that the latter be provided with a stop-cock. By attaching several branches to tube *d*, any number of water-baths may be kept supplied at one and the same time. (Klement.)

According to Pomeroy's plan, a tube of glass or metal, not less than $\frac{1}{4}$ in. internal diameter, the ends of which are cut off obliquely (this is necessary), is bent as shown in Fig. 86. It should make an angle of about 30°, or a little greater, with the horizon, and the angle may be

increased if the bore of the tube is increased. One end is inserted into the water-bath, the other into an inverted bottle. The height of the water in the

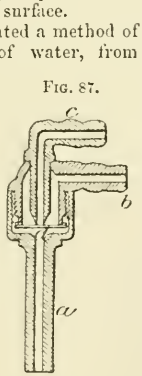
FIG. 86.



bath is regulated by the depth of immersion of the tube in it. The boiling is not interrupted by the feeding, which takes place slowly and regularly. The same form of tube answers equally well for keeping a constant level of fluid in a filter or drying chamber. A brass tube is much better than one of glass, as it does not crack at the water level after use for a time. To bend brass tubes, ram them full of sand, stop the ends, and bend over a curved surface.

Seelig has communicated a method of preventing the loss of water, from evaporation, in drying ovens; and of confining the consumption of gas, at the same time, to the smallest possible quantity. The outer shell of the drying oven must have only *one* exit, communicating with the water space between the walls. Into this opening, the apparatus shown in Fig. 87 is firmly fastened by means of a perforated stopper surrounding the leg *a*. The lateral branch *b* communicates with the source of gas, and the branch *c* is connected with the burner under the drying

FIG. 87.



oven. The tube *a* is expanded above, and closed by a rubber membrane *d*. This prevents, in the first place, loss of the water by evaporation. As soon as the tension of the steam in the apparatus has become higher than it was at the time of adjusting the apparatus, the membrane bulges upwards, closes the outlet of tube *c*, and thereby diminishes the supply of gas to the burner. The total extinction of the flame is prevented by a scant supply of gas reaching the burner through a small lateral opening in the inner leg of *c*. It will be readily seen that, if the apparatus is adjusted at the time when the water has actually reached the boiling-point, it may be kept for any length of time at the temperature of boiling water without having to renew the latter. (*Zeit. An. Chem.*)

DISTILLING.—The scope of this article is confined to simple distillation of fluids, such as the distillation of water to free it from non-volatile impurities, and the distillation of spirit to remove combined water. These processes and the apparatus pertaining thereto are capable of wide application and utility.

Water.—The total absence of potable water in many parts of the world, to which the existence of valuable mineral deposits attracts a considerable population, has called for the invention of some artificial means of supplying this, the greatest of all the necessaries of life. Perhaps in no part of the world has more attention been given to the subject than in the northern part of Chile, "the desert of Atacama." This region was traversed by Indian posts in the time of the Incas, the runners being supplied with water at various points on the road, with an immense expenditure of labour. The water was carried long distances, in large earthenware jars; and the inconvenience was reduced to a minimum by the care bestowed in laying out the roads, so as to take the greatest advantage of the fresh-water springs at the foot of the Andes.

About 30 years since, the method of procuring fresh-water from the sea by

distillation was commenced. The original form of apparatus, and one that is even now largely in use, consisted merely of a Cornish boiler, the steam from which passed through a coil of wrought-iron pipes in an open tank, often of wood. Various improvements have been made from time to time, principally in the direction of enclosing the coils and conducting the steam given off to secondary, and thence to tertiary, condensers, similar to the apparatus designed by the late Dr. Normandy. The ordinary consumption of coal per unit of water in the original open condensers is about $\frac{1}{6}$, but with several condensers and an air-pump on the last, a ratio of $\frac{1}{16}$ is regularly obtained in daily work.

A serious inconvenience attending this method of production arises from the excessively bad quality of the water for use in a steam boiler, as it contains about 14 per cent. of salts—the principal of which are sodium chloride, and lime, soda, and magnesia sulphates. The freight on coals from the port, too, is enormous, amounting, at the time when the apparatus was designed, to 3–3½ dollars per 100 lb. Taking into consideration the loss on the road, and the expense of repairs to boilers, condensers, &c., the cost of the water was about 4 cents per gallon.

With a view to overcoming this difficulty, an apparatus for the distillation of water in Las Salinas, by the action of the sun's rays, was designed by Charles Wilson in 1872. Las Salinas is situated about 70 miles inland from the port of Antofogasta, and is about half-way on the road to Caracoles, a great silver district, requiring, when in full work, the employment of about 800 carts and 4000 mules, which passed through Salinas, on an average, about once a week. The site selected for the establishment was a smooth plain, with an inclination of about 1 in 100 towards the old watercourse, in which are wells for salt water. The apparatus consists essentially of a number of long shallow troughs, filled with water, and covered by a sloping glass roof. The water is evaporated by the sun's rays passing through the glass; the vapour is condensed on the under surface of the glass, runs down to grooves cut in the wooden frame, and thence, by a system of pipes, to the fresh-water tank. There are in the establishment at Salinas 64 frames, each 200 ft. long by 4 ft. broad, giving a total area of 51,200 sq. ft. of glass. Each frame is composed of 2 principal parts, the water-trough and the roof. The trough is constructed of 3 longitudinal sleepers, 4 in. by 4 in., on which the planking (1½ in. thick) is laid. The sides are composed of timbers, bolted to the sleepers at every 6 ft., the whole being carefully jointed inside with putty, to render it perfectly water-tight, and having an inclination of about 1 in. in the total length in the direction of the wash-out plug. The roof is constructed in 10 lengths of 20 ft. each. The sides are of pine, with the upper edge properly cut to receive the glass, and a groove for conveying the condensed water to the outlet-pipes, which are placed at the lower end of each section, the grooves having an inclination of 2 in. in 20 ft., in addition to the inclination of the trough. The end frames of the 20-ft. sections of the roof, excepting those which coincide with the ends of the troughs, are carried down to a little below the water-level, to prevent the escape of vapour in the joint, there being, in fact, no outlet for the vapour, excepting by the small leaden pipes which carry off the condensed water. The ridge is supported by the end frames and intermediate uprights, resting on the bottom of the trough. The sash-bars are movable, so as to suit varying widths of glass.

The salt water is admitted by a 1-in. brass cock at the higher end of the trough, and a wooden plug for washing out is provided at the lower end. There is also, at the lower end, an overflow pipe, the point of which is turned down below the water, to prevent the escape of vapour. The salt water is pumped from the wells by a windmill into a tank at the upper end of the grounds, sufficiently large to contain about 4 days' supply. The water from the tank

is distributed to the various troughs by a 2-in. wrought-iron pipe, with the necessary connections. The fresh water is collected from the small leaden pipes into a 1½-in. wrought-iron pipe running between the troughs, and connecting with a 2-in. main-pipe at the end, which leads to the storage tanks. To increase the evaporation, the bottoms of the troughs are blackened with logwood and alum, and are washed out every second day, by running salt water through them.

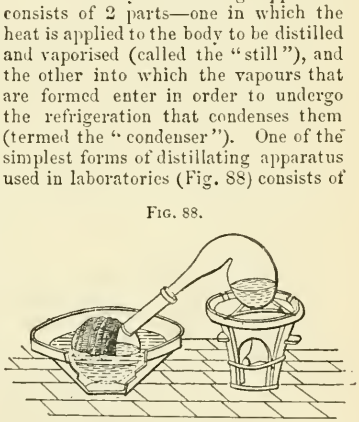
When first set to work, the establishment produced daily, in summer, upwards of 5000 gal. of fresh water, about equal to 1 lb. of water per sq. ft. of glass; but after the opening of the railway, the owners grew careless, and allowed the troughs to get out of repair, so that, through leakages and insufficient cleansing, the production gradually fell off to about ⅓ of the above. When not properly attended to, crystals of soda and lime sulphate (Glauberite) form in the troughs, directly diminishing the production, and indirectly leading to loss by leakage when the crystallisation takes place between the planks, and so forcing open the joints. When properly maintained, the cost of water, including interest on capital, renewals of glass, &c., amounted to less than 1 cent per gallon. The principal item of expense is the renewal of glass broken by whirlwinds, which are very frequent in the locality. The staff consists of a clerk, who keeps the accounts, sells the water, and manages the business generally; and of a glazier, and 2 labourers for cleaning and repairs, and at intervals a carpenter to restore the woodwork.

The frames being laid on the ground, it is difficult to discover a leak, and the wood in the sides of the roof, between the fresh-water groove and the salt water, is apt to crack in the part above the level of the salt water, and cause a loss of fresh water by its leaking back into the trough. The first defect could be remedied, at a moderate cost, by raising the longitudinal timbers on cross-sleepers placed 4 or 5 ft. apart, and the second defect by lining the grooves with thin sheet-lead or tin. In the warm vapour under the glass, iron is very quickly destroyed. The temperature of the water in the troughs at noon (when the thermometer stands at 80° F. in the shade), is 140° to 150° F. The distillation usually begins at about 10 A.M. and ends at about 10 P.M.

Some experiments were made, but very incompletely, to try the effect of warming the water in a boiler before it entered the troughs, especially for use during the night and early morning. From the little that was done, it appeared probable that good results might be expected. On cloudy days, the production is less than one-half, about 40 per cent., of that on sunny days. Cloudy days are, however, very rare in the locality. (Harding.)

All ordinary distillating apparatus consists of 2 parts—one in which the heat is applied to the body to be distilled and vaporised (called the "still"), and the other into which the vapours that are formed enter in order to undergo the refrigeration that condenses them (termed the "condenser"). One of the simplest forms of distillating apparatus used in laboratories (Fig. 88) consists of

FIG. 88.



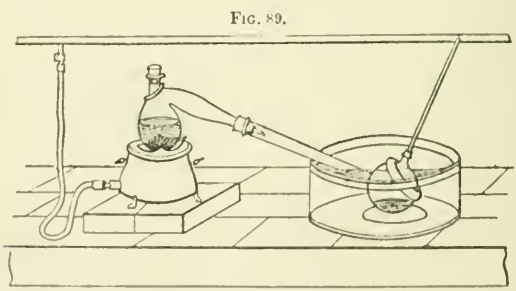
a still into which is introduced the liquid to be distilled, and which is placed upon a furnace. The neck of this fits into that of a sphere whose opening must be wide enough to allow the orifice of the still to reach the spherical part of the receiver. Finally, the sphere dips into a vessel full of cold water, and is cooled on its external surface by a wet cloth. The heated mixture begins to boil, and its vapours,

escaping from the retort, cool and condense upon the cold sides of the spherical receiver. This latter serves at once as a refrigerator and a vessel for receiving the distilled product.

In the beginning, the empty receiver weighs less than the volume of water that it displaces, and tends to float. It is often kept in the water by placing a weight (a brick, for example) upon the top of its spherical part and upon the sides of the vessel containing the cold water. The want of stability of this much used arrangement makes it unrecommendable. It is preferable to make use of a sufficiently heavy ring of lead into which the neck of the receiver may be introduced, and which may rest upon the latter's bulge. Upon fixing a similar ring under the receiver, the latter will be prevented from turning laterally and even from getting broken. The water in the external vessel is renewed so as to keep it cold.

A simple arrangement of this kind is not adapted for materials that have a low boiling-point, since a large proportion of the vapours escapes, and makes its exit through the neck of the receiver, which is kept hot by the vapours coming from the still. The following, which is just about as simple, is a much more perfect arrangement.

FIG. 89.



The narrow part of the still is fixed into the neck of a long, tubular receiver (Fig. 89) by means of a cork which it traverses. This annular cork exactly closes the space between the neck of the still and that of the receiver. On the other side, in the tubulure of the receiver there is fixed, by means of a cork, perforated and arranged like the preceding, a long and narrow glass tube.

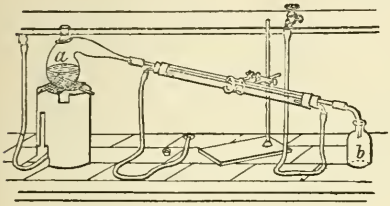
When the still has been filled with the substance to be distilled, and placed upon a furnace covered with wire gauze, the receiver is immersed, as above stated, in cold water. The vapours that are formed become cooled in traversing the elongated neck of the receiver, and are thoroughly condensed in the immersed part, provided the ebullition is not too rapid. In this latter case, the narrow tube, which presents the only open orifice, becomes heated, and indicates to the operator that the fire must be moderated.

The inconvenience of every apparatus of this kind is that the vapours which enter the receiver are not compelled to impinge against the sides, and may go directly to the exit-tube, or, in other words, the refrigeration is not methodical. Moreover, the refrigerating surface continues to diminish in measure as the receiver fills. Finally, if the receiver breaks, the entire distilled product comes in contact with the water. Despite these disadvantages, the rapidity with which such apparatus may be arranged causes them to be frequently employed.

The use of refrigerators permits of a more exact and methodical condensation of the vapours. These are arranged as follows: The 2 orifices are placed in contact by means of a rubber tube, 3 to 4 *cm.* in length, into one end of which

is introduced the neck of the retort *a* (Fig. 90), and into the other the tube of the refrigerator. The latter being held in an inclined position by means of a clamp, a current of water traversing

FIG. 90.

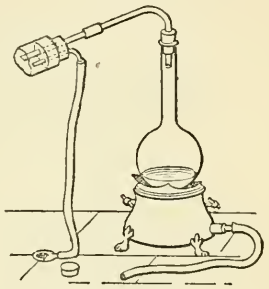


it from top to bottom, and a bent tube being adapted to its lower extremity, the free extremity of the bent one is fixed into the flask that is to collect the product. We may also suppress the central tube of the refrigerator in the flask *b*, kept inclined. To facilitate this arrangement, the neck of the retort is cut at a point where it has the same external diameter as the tube of the refrigerator, and is then edged with a flame. Again, if the difference between the diameters is considerable, we may, by means of a flame, draw out slightly the one of the two tubes that is the larger, and cut it at the proper point to obtain an equality in the diameters. Finally, we may solder to the extremity of the refrigerator a cylindrical tube, 2 or 3 *cm.* in diameter and 6 or 7 in length, into which is fitted the neck of the retort previously provided with a cork. This latter contains an aperture running in the direction of its axis, and the whole is arranged so as to form a tight joint.

When the substance distilled attacks cork and rubber, the neck of the retort is drawn out to a sufficient length to allow the tube that terminates it to enter the refrigerator to some depth. The rubber with which the 2 parts of the apparatus are connected is thus nearly out of the range of the vapours.

It is very evident that the still may be replaced, and advantageously too, in many cases, by any other spherical vessel with a narrow neck. In this case the receiver is closed (Fig. 91) by a cork or rubber stopper containing an aperture that is traversed, through slight friction, by a glass tube. This latter is so bent that the angle formed

FIG. 91.



by its 2 branches shall correspond to the inclination that is given to the refrigerator. The external extremity of the tube is connected with the refrigerator by means of one of the arrangements described above for the neck of the retort. As for the internal extremity, it is well, especially if the tube is narrow, to bevel it off so as to facilitate the flow, drop by drop, of the condensed liquid which accumulates therein, and which, without such a precaution, might be carried along by the vapour toward the refrigerator. Moreover, in the case of a liquid that would attack the joints, the bent tube that fits into the neck of the receiver may be that of the refrigerator itself.

One of the best forms of still for the photographer to employ consists (Fig. 92) of a tin can or bottle in which the water is boiled, and to this a tin tube is adapted by means of a cork, one end of this tin tube terminating in a coil passing through a tub or other vessel of cold water. A gas burner, as shown, is a convenient source of heat, and in order to ensure a complete condensation of the vapour, the water in the cooling tub must be changed now and again.

Sometimes the vapour is condensed by being allowed to play against the inside of a conical cover which is adapted to a saucepan, and is kept cool by the external application of cold water; and in this case the still takes the form represented by Figs. 93, 94, and 95; such compact and portable stills being largely employed in Ireland for the private manufacture of whisky.

FIG. 92.

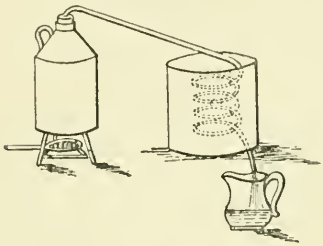


FIG. 93.

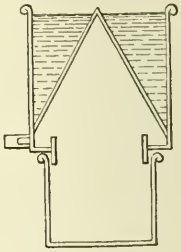


FIG. 94.

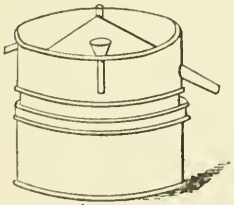
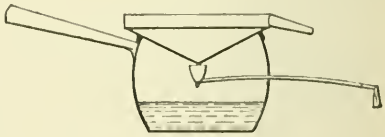


FIG. 95.



It is scarcely necessary to say that the condensed water trickles down on the inside of the cone, and flows out at the spout.

An extemporised arrangement of a similar character may be made by passing a tobacco pipe through the side of a tin saucepan as shown in Fig. 93, and inverting the lid of the saucepan; if the lid is now kept cool by frequent changes of water inside it, and the pipe is properly adjusted so as to catch the drippings from the convex side of the lid, a considerable quantity of distilled water may be collected in an hour or so.

The proportion of solid impurities present in water as ordinarily met with is extremely variable; rain water which has been collected toward the end of a storm contains only a minute fraction of a grain per gallon, while river or spring water may contain from less than 30 gr. per gallon or so upward. Ordinary sea water generally contains 3–4 per cent. of saline matter, but that of the Dead Sea contains nearly $\frac{1}{4}$ of its weight of salts.

The 3 impurities of water which most interest the photographer are lime or magnesia salts, which give the so-called hardness; chlorides (as for example, sodium chloride or common salt), which throw down silver salts; and organic matter, which may overturn the balance of photographic operations by causing premature reduction of the sensitive silver compounds. To test for them is easy. Hardness is easily recognisable by washing one's hands in the water, the soap being curdled; but in many cases one must rather seek for a hard

water than avoid it, as the tendency of gelatine plates to frill is far less in hard water than in soft water. It is, indeed, a common and useful practice to harden the water used for washing by adding ½–1 oz. of Epsom salts (magnesia sulphate) to each bucket of water. Chlorides—sodium chloride or common salt being that usually met with—may be detected by adding a drop or two of silver nitrate to half a wineglassful of the water, a few drops of nitric acid being then added. A slight cloudiness indicates a trace of chlorides, and a decided milkiness shows the presence of a larger quantity. If it is wished to get a somewhat more definite idea of the amount, it is easy to make up a series of standards for comparison, by dissolving known weights of common salt in distilled or rain water, and testing samples of them side by side with the water to be examined.

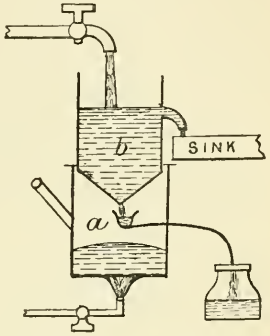
Organic matters may be detected by adding a little silver nitrate to the water, filtering off from any precipitate of silver chloride, and exposing the clear liquid to sunlight; a clean stoppered bottle being the most convenient vessel to use. The extent to which a blackening takes place may be regarded as approximately proportionate to the amount of organic matter present.

Filtration on a small scale is not altogether a satisfactory mode of purifying water, as organic impurities often accumulate in the filter, and enter into active putrefaction when hot weather sets in. (*Photo. News.*)

The simple apparatus shown in Fig. 96 works admirably, and is very convenient. *a* is a common tin saucepan, with a small hole in the side, for a tobacco-pipe; *b*, a "steamer," on top, with a bottom like an inverted cone, 1 in. of wire being soldered at the apex. A gas jet (Bunsen's, if possible) boils the water in the saucepan; the ascending steam is condensed on the lower surface of the steamer, runs down to the point of the wire, down the pipe into the bottle. A small jet of cold water keeps *b* cool.

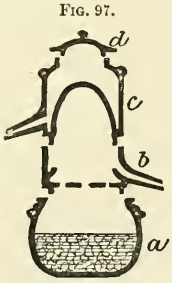
Fig. 97 illustrates a little earthenware distilling apparatus in use among the Japanese. It consists of 4 pieces: a boiler *a*, on to which fits a short

FIG. 96.



cylinder with a perforated bottom *b*, and over this a condenser *c*, with a cover *d*. The cover being removed, a stream of cold water can be kept

FIG. 97.

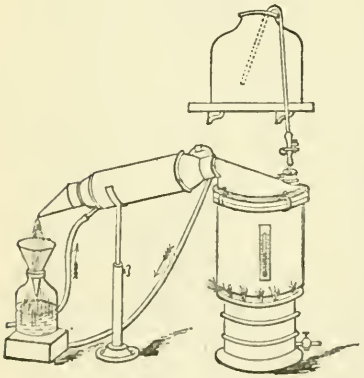


running into the condenser by means of a bamboo, and the overflow carried off by the spout at its base. Round the base of the inner side of the middle cylinder runs a ledge which forms a channel opening into an exit spout. The materials for distillation are put into the boiler, and the whole is placed on the ordinary *hibatchi*, or domestic fire-box. The vapour passes through the perforated bottom of the cylinder, collects in drops on the dome-shaped

inner surface of the condenser, runs down into the channel before described, and is collected at its exit from the spout. This little contrivance is known by the Japanese under the name of *lambik* or *rambiki*, which is doubtless some corruption, through the Dutch, of the word alembic. In the country districts peppermint is largely used as a corrective for water rendered muddy and otherwise unsuitable for drinking by rains, as well as for other domestic purposes, and this apparatus is one of the means employed for its distillation.

Tinctures, Extracts, &c.—A very convenient and complete still is shown in Fig. 98. The body holds over

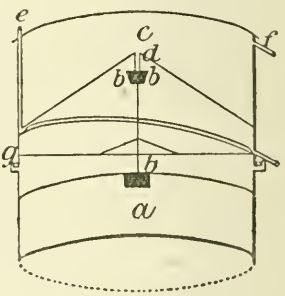
FIG. 98.



3 gal.; the condenser has 7 straight tubes surrounded with the cold water introduced by a rubber tube from a hydrant or bucket of water placed higher than the still, and carried off as it becomes warmed by another tube as indicated by the arrows. By the siphon arrangement shown in the cut, it is possible to feed the still from a reservoir whilst distillation is in progress, thus using a 3-gal. still where a much larger one would have been necessary. The still may be set into a kettle partly filled with water and thus used as a water-bath, or a shallow dish with flat rim, which accompanies the still, may be placed between the 2 brass ring bands and clamped securely.

Having for some time been in need of an apparatus for distilling a quantity of water at a time, and finding none in the market answering the purpose, A. B. Stevens, of Detroit, Mich., arranged the apparatus shown in Fig. 99

FIG. 99.



for continuous distillation, which has thus far answered all that is required of it. As soon as the water passes out of the boiler *a* the float *b* lowers, letting a fresh supply of water from the condenser *c* through *d*, thereby keeping the water in the boiler at a constant level. This avoids the necessity of adding a large quantity of cold water at once, the effect of which would be to reduce the temperature of the water below the boiling-point.

Cold water is supplied to the condenser through *c*, and as it becomes heated and rises to the top, it is carried off through *f*. The boiler and condenser are joined at *g*.

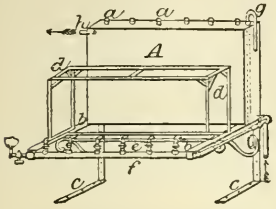
By leaving out the float and closing the inlet *d* with a cork, it can be used for distilling various things as well as water.

The apparatus is not patented, and should any pharmacist desire to make one for his own use he can do so; should he prefer one ready-made, Stevens will furnish them to order, size 10 in. diameter, all of copper, with 6 ft. of rubber tube, for 8 dollars (say 35*s*.).

For the purpose of distilling a series

of samples at one time, Dr. B. Landmann has devised an apparatus which appears to be very compact, and may be fastened against the wall, so as not to interfere with other available space in the laboratory. It consists (Fig. 100) of

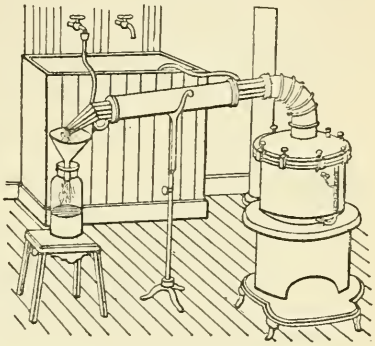
Fig. 100.



a common, tinned-iron cooler *A*, $21\frac{3}{4}$ in. long, 12 in. high, and 2 in. deep, with a series of openings *a*, for passing through the condensing tubes, and an inlet and outlet for water, *g* and *h*. The cooler stands upon 2 iron supports *b*, about $9\frac{3}{4}$ in. long, to the front ends of which is attached the gas-pipe *f*, which is provided with 6 stop-cocks and a lateral burner. The 2 iron supports are firmly held in place by the 2 parallel rods *c*, and the iron framework *d*, which is $1\frac{3}{4}$ in. distant from the cooler, has a height of 8 in., and a width of $2\frac{3}{4}$ in. The receivers are placed upon a board which is laid across the supports *c*. As it is necessary that quite a number of connecting tubes should be on hand, it is advisable to bend them all after a pattern or drawing made upon a board. Should the corks through which the cooling tubes *a* pass not be sufficiently tight, it is only necessary to pour melted paraffin through the orifice *g*, until it has coated the bottom of the apparatus.

The distilling apparatus represented in Fig. 101 is intended primarily for the use of pharmaceutical chemists or druggists, but it possesses features which will recommend it to many who have need of a trustworthy and quick-acting still. The wide delivery tube is a useful feature, allowing as it does for the accumulation of vapour, and permitting the introduction of the hand. The body of the still is of wrought iron or copper, with a lid fitting on ground edges, and held together by screw-clamps, as seen in the engraving. A gauge is fitted to

Fig. 101.

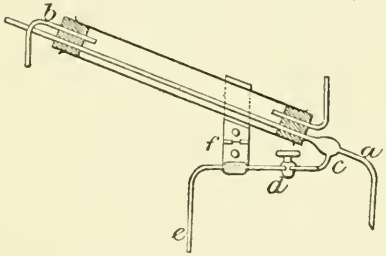


show the quantity of liquid in the still. The condenser consists of a number of glass tubes, which, if they are 1 in. diameter and 24 in. long, expose a surface of 264 in., while that of the surrounding cylinder is only $188\frac{1}{2}$ in. The ends of the condenser tubes are drawn together and tapered, as shown in cut, to permit, if desired, the collection of the distillate in a narrow-mouthed bottle. The advantage gained by this apparatus, aside from the general one of convenience, is thus seen to be in the notable increase of condensing surface it exposes, which to that extent increases the effectiveness of the device—i. e. its rapidity of action. Compared with a Liebig condenser of similar dimensions, this apparatus exposes probably 3 times as much condensing surface. The idea of a tubular condenser, employed in the manner set forth, is, in the opinion of the *American Journal of Pharmacy*, an excellent one, that may find useful imitation in the chemical laboratory and elsewhere. The device illustrated and described was invented by Joseph P. Remington, whose recommendation of its merits is

based upon a continuous use of it for 3 years.

In chemical or pharmaceutical operations, it often becomes necessary, after having used an upright condenser for the purpose of continuous extraction, to reverse the whole condenser, in order to recover the volatile menstruum. This also necessitates, in most cases, a change of the current of water for cooling the apparatus. All this may be avoided by constructing the condensing tube in the manner shown in Fig. 102. From a

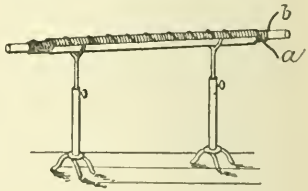
FIG. 102.



bulbous expansion blown in the tube at its lower end, a tube *c* arises, provided with a faucet *d*, and subsequently turned at a right angle downwards. At about the centre between the faucet and the angle, the glass tube passes through a support connected with the condenser, whereby it is in a great measure protected from being broken off. The use of this modified condenser is almost self-evident. If it is used for continuous extraction, so that the condensed liquid constantly flows back into the flask connected with *a*, the faucet at *d* is closed. The condensed liquid will then at first fill the tube *c* until it flows over into the tube *a*. Finally, when the operation is to be finished, a receiver is placed under *e*, and the faucet is opened, when all the condensed liquid may be collected without disturbing the connections of the condenser. It is advisable before opening the faucet *d* to dip the end of the tube *e* into a flask containing a portion of the liquid which is to be distilled over, f. i. ether. The depth to which the tube may be dipped should be less than the length of the column of liquid contained between *c* and *d*. (Simand.)

Dr. Carl Roth draws attention to a condenser lately devised by him. He was led to its construction by the frequent breaking of the tubes in Liebig and Hoffmann condensers, in which latter the water immediately surrounds the tube containing the vapour. While, ordinarily, there is little danger of the tubes bursting, they are, nevertheless, quite liable to do so in cases of the distillation of absorption products.

FIG. 103.



Dr. Roth's condenser, as Fig. 103 shows, consists of a glass tube aroundd which is wound a thin leaden pipe of 10–15 times the length of the glass. The pipe is first wound with the convolutions close together, and is then brought back in large turns. This arrangement allows the water to be heated somewhat before it gets close to the glass, and in addition it utilises to a greater extent than in the old form. Its efficiency can be increased still more by placing tinfoil upon the glass before winding the tube. Another advantage of the apparatus is, that in case the glass tube bursts, the distillate will not be in danger of becoming mixed with water.

Dr. Roth states that he has used this form successfully in experiments that would inevitably have caused the destruction of Liebig's condenser. In the figure the water enters at *a* and flows out at *b*. (*Dingl. Pol. Jl.*)

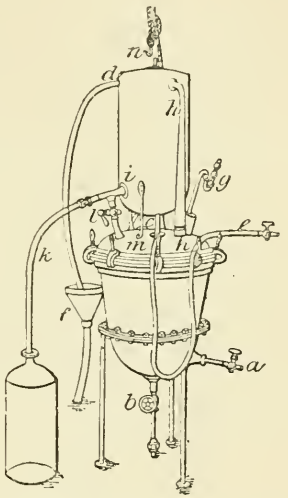
The stills which are used by pharmaceutists or chemists are usually pro-

vided with a head terminating in a tapering pipe, which is intended to be connected to the worm or condenser. This connection, however, is, in many cases, quite awkward, and often a source of loss from leakage. Those who have had much occasion to work with such an apparatus will fully appreciate the truth of this. In large stationary stills, used on a manufacturing scale, the condenser consists of several parts; the so-called column, a series of vessels, which the vapours have to traverse, and in which all that part of the vapour condensable below a certain temperature is reduced to the liquid condition, and returned to the still; and in addition to this a regular worm or condensing cooler. Such arrangements are, however, too circumstantial for small stills.

To obviate the difficulties above mentioned, Rice has constructed a new form of still-head and condenser, which completely answers all demands made upon it. It requires *one* packing, may be used as a reflux-condenser, and saves a great deal of room, from the fact that a special worm-tub is made unnecessary. Fig. 104 gives a correct representation of the apparatus.

It consists mainly of 2 parts; the still and the head with condenser. The still has a capacity of 16 gal., and is heated by steam, which enters at *a*, *b* being the exhausting pipe. The still-head is constructed of tolerably heavy copper, to be able to bear the weight of the condenser, which is fastened to it by 3 iron legs, attached with rivets. The condenser is a cylindrical copper vessel, of the capacity of about 10 gal., with rounded bottom and closed top, having short ½-in. tubes projecting from the bottom and from the top—at *c* and *d*. There are 2 such tubes at the bottom, one for attaching the rubber hose *e* bringing the water; the other, shown in the cut immediately alongside the letter *c*, is closed with a cork, and is used to permit the water to be emptied without detaching the hose from the other. At the top there are likewise 2 tubes, one at *d*, for attaching rubber hose to carry off the water into the waste-pipe *f*; the other, being closed with a cork, is not shown in the cut, as it is on the back of the condenser.

FIG. 104.



The head of the still carries 3 short tubulures, only one of which is visible in the cut, and which contains a cork bearing the safety-valve *g*. Another opening is at the other side, for refilling the still when required; and yet another narrower tube, intended for the insertion of a thermometer. The condensing-pipe begins at *h*, where it rises from the head parallel with the condenser. It is made of copper as far as the point indicated by the upper *h*, where it is soldered to the *downward projecting* upper end of the block-tin worm contained in the condenser and emerging from it at *i*. This arrangement makes it impossible for any condensed liquid to come into contact with anything but block-tin. The worm, inside the condenser, is made by carefully winding upon a round block of wood 20 ft. of ¾-in. block tin pipe, taking particular care that the coil has

a uniform downward descent throughout. After emerging from the condenser at *i*, it extends for a short distance, where the cut shows it to be connected to the separate block-tin pipe *k* by means of a union joint lined with tin. Half way between *i* and the end proper of the worm, the pipe is tapped, and a branch, carrying the faucet *l*, leads into the still *m*, where it terminates under the centre of the head in the shape of an ∽, forming a trap to prevent the escape of vapours by this passage. The object of this arrangement is to cause the condensed liquid to flow back into the still as long as the faucet *l* is open, or to collect it outside by turning off the faucet *l*. Prolonged digestions with alcohol may be made by means of this apparatus, without any loss of liquid. The head is attached to the still by means of a rubber washer and iron clamps, and when it is desired to remove it, the water is allowed to drain from the condenser, the clamps are removed, and the whole is hoisted up by the tackle *n* and set on one side.

To illustrate the use of the faucet *l* by an example, we will suppose that we have to completely exhaust 10 lb. of powdered nux vomica. Into a frame fitting into the upper part of the inside of the still is fitted a broad, short, copper percolator, which is packed with the powdered nux vomica. The head and condenser being connected with the still, about 3 gal. of alcohol are poured into the still, and the water having been turned on the condenser, and flowing briskly, steam is carefully turned on at *a*. The faucet *l* is kept closed as yet, and the pipe *k* is made to point into a receiver. As soon as condensed alcohol flows into the latter in a steady and uniform stream, the faucet *l* is opened, when the flow of alcohol returns to the still, and empties itself from the end of the ∽ over the centre of the percolator. From time to time the faucet is closed, and the regularity of the flow is observed, as it empties itself into the receiver. After a certain lapse of time, depending upon various circumstances, and mainly upon previous experience—in the present instance, after about 4 hours—the nux vomica is completely exhausted, and the last part of the operation consists in turning off the faucet, and permitting all the alcohol to run into the receiver.

Rice is in the habit, when using the apparatus for such purposes, of placing in the still 2 gal. of ordinary glycerine, and in this a large porcelain pot, supported in such a manner that the glycerine surrounds it on all sides up to within about 4 in. of the top. The liquid to be distilled, such as alcohol, is placed in the dish, the distillate, if required to be used as a continuous menstruum, is made to run back into the still, where it flows into the dish, and finally, after distilling off the alcohol, the dish is removed with the extract contained in it. If the tincture is allowed to run directly into the still, and the alcohol is distilled off, it requires considerable labour and waste of alcohol to remove the extract, besides incurring the danger of overheating and almost baking it.

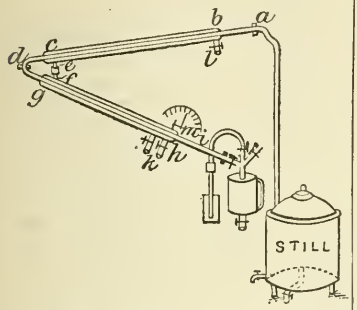
In all cases, when possible, it is recommended to place in the still a preliminary charge of water, say ½–1 gal., and to distil this over to dryness. The packing thereby swells up and becomes tight, so that when the alcoholic liquid is introduced no loss will be incurred.

The apparatus is *not* patented, and Rice places it at the disposal of any one who wants to use it. (*New Remedies.*)

An improvement on Liebig's condenser is proposed by Abraham. In the old form, the water, heated by vapour in the coil, *very slowly* rises upwards, mixing at the same time with the surrounding water and producing a *large quantity of warm water*, which has to be removed to keep the coil cool. In a properly constructed Liebig's condenser, however, a rapid *current* of water should drive that in front of it farther and farther *without materially mixing with it*, until at last it is driven out at a very high temperature, having done all, or nearly all the work it possibly could. In Fig 105, the dimensions

are: *a–b*, 6 in.; *b–c*, 10 ft.; *d* is a steam-tight joint; *e f*, ¾-in. tubes, nearly meeting, not joined; *g–h*, 8 ft.; *h–i*, 2 ft.; *k*, stop-cocks for supply of other

FIG. 105.

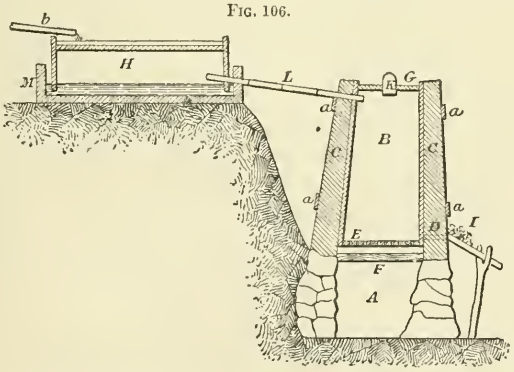


condensers; *l*, hot-water exit; *m*, stop-cock, with index to regulate flow of water. In designing his new condenser Abraham went on this principle, and not only had his outer or cooling tube as small as possible, but, to further increase its condensing powers, had a thick copper wire wound spirally round the inner tube so as to compel the water to rotate at a high speed. Diameter of internal tube, 1 in.; diameter of external tube, 1½ in.; both No. 16 wire gauge copper tubing.

The old coil was only capable of condensing 4 gal. per hour, and did not always cool that quantity as completely as is desirable for the purpose of distillation *in vacuo;* in order to ensure against possible failure, and to increase if possible the condensing power, the new one was made, if anything, slightly longer than the old. The efficiency of this condenser is such that it would, if only half its present length, condense and cool perfectly about 6 gal. of liquid per hour. Not only is its condensing power highly satisfactory, but it occupies next to no space, as it is fixed to the wall; it is more cleanly and, what is perhaps of more advantage than anything else, it is very easily cleaned by driving steam through it, whereas a tube requires to be emptied before this can be done.

The wet distillation of camphor is an instance of the adoption of this process for extracting organic products. The most general arrangement of the still and condenser, adopted in the Tosa district of Japan is shown in Fig. 106. On a small circular stone wall A, serving to form a fire-place, lies an iron plate F, 2½ in. thick.

FIG. 106.



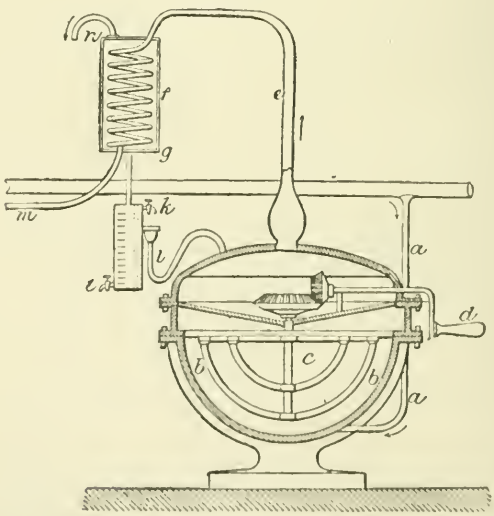
This is covered by a numerously perforated lid, luted tightly with clay, which at the same time forms the bottom E of the vessel B, which is 3 ft. 4 in. high, and 18 in. wide at the top. Near the bottom is a square opening D, which

may be closed by a board. The whole is clothed with a thick coating of clay C, held fast by a binding of bamboo hoops *a*. The upper opening is closed by a clay-luted cover G, having a hole in the centre, furnished with a cork K. Just under this cover, a hollow bamboo stem leaves the still and passes to the condenser *h*. This consists of a 4-sided box open beneath, divided into 5 intercommunicating compartments by means of 4 partitions, and turned with its open side into a vessel M containing water. This condenser is kept constantly cool by a stream of water, led over the top by means of the pipe *b*. The distillation is conducted in the following way. After removing the cover G, the vessel B is filled with the chips of camphor wood, the cover is replaced and well luted with clay; then through the opening K, a certain quantity of water is run in, which, after saturating the chips, will collect in the pan F. Gentle firing is now commenced, and is continued for 12 hours, so as to keep the water in F at a steady boil. The ascending steam, finding its way among the chips, carries all the camphor with it, and on condensation in the cooler H, the camphor is deposited, and removed at suitable intervals.

Such a simple and efficient apparatus ought to afford a valuable hint to many a colonist who wishes to utilise natural products of a similar character.

To obtain the essential oils from flowers, plants, or seeds, the oleiferous material is placed in an iron, copper, or glass still, of 1–1000 gal. capacity, and is covered with water; superposed is a dome-shaped lid, terminating in a coil of pipe, placed in a vessel of cold water, and protruding therefrom with a tap at the end. On boiling the contents of the still, the essential oil passes over with the steam, and is condensed with it in the receiver; the oil and water separate on standing. A great improvement, introduced by Drew, Heywood, and Barron, is the use of a steam-jacketed still, as shown in Fig. 107. Steam is sup-

FIG. 107.

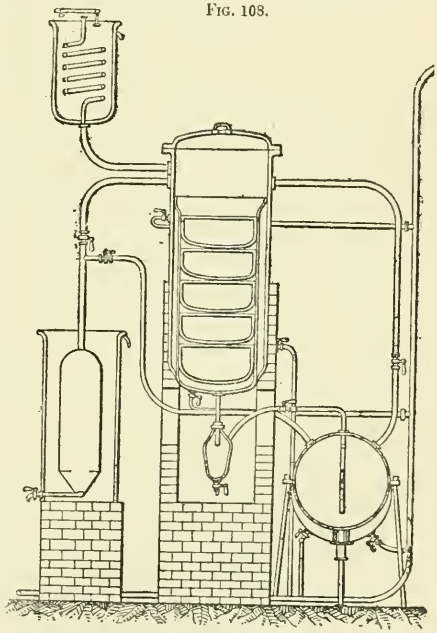


plied from a boiler by the pipe *a* into the jacket *b*; within the head of the still, is fixed a "rouser" *c*, a double-branched stirrer curved to the form of the pan, and having a chain attached and made to drag over the bottom, the whole being set in motion by means of the handle *d*. The still is charged, and nearly filled with water; the head is then bolted on, steam is admitted into the jacket, the contents are well stirred, and soon the oil and steam are carried up the pipe *e*, condensed in the refrigerator *f*, and let out at *g* into the receiver *h*. Here the oil and water separate, and escape by different taps. In the illustration, it is supposed that the oil obtained is heavier than water; it will then sink, and be drawn out by the lower tap *i*, and, as soon as the water reaches the level of the upper tap *k*, it will flow into the siphon-funnel *l*, and thence into the still. Thus the same water is repeatedly used in the still. The pipe *m* conveys cold water into the refrigerator *f*; the water escapes as it becomes hot by the pipe *n*. When the oil distilled is lighter than water, the taps *i k* exchange duties. Before commencing operations, the siphon *l* is filled with water to prevent the escape of vapour.

An apparatus recently constructed by Rigaud and Dussart is arranged so that dry steam enters directly among the matters to be distilled, and the temperature is always maintained at a high point. This is shown in Fig. 108. It is claimed to yield a larger and superior product, and to prevent all chance of creating an empyreumatic odour, such as sometimes happens with other forms.

Distillation as a means of obtaining essential oils is worthy of every consideration. Generally it should be effected by steam; but there are cases (bitter almonds, &c.) where contact with water is necessary for the production of the oil, while in others, open fire and steam are equally applicable, though the latter is superior. The water employed must be perfectly pure and neutral, though in some cases (sassafras, cloves, cinnamon, &c.) common salt is added to raise the boiling point. The receiver is always some form (there are many) of "Florentine receiver."

FIG. 108.



In some instances (anise, &c.) where the distillation-products are solidifiable at a low temperature, the condenser-worm needs to be warmed instead of cooled.

Spirit.—The distillation of spirit is performed for the purpose of separating the alcohol more or less from the water. The boiling point of water at the ordinary standard pressures of the atmosphere, equal to 30 in. of mercury, is

212° F. (100° C.), that of alcohol 173·1° F. (78·5° C.). At the sea level, the pressure of the atmosphere may frequently vary between 28·5 and 30·5 in.; the boiling points of water corresponding to these temperatures are 210° F. and 213° F. Indeed, changes in the weather may cause the boiling point of water to vary as much as 5° F. in our climate. These alterations in pressure would cause corresponding changes in the boiling point of alcohol. If we gradually raise the temperature of alcoholic fluids to a point when vapours are freely formed, it is observed that though there is a continuous absorption of heat, yet the liquid does not increase in temperature. The heat which is absorbed during the first period is doing work of a different character from that employed subsequently. There are two phases in the process, and two different kinds of work performed by the heat employed in boiling even a kettle of water.

The first phase is indicated by a rise of temperature from 60° F. to 212° F.; the second phase by a change of state, from that of a liquid at 212° F. to a vapour at the same temperature. The quantities of heat required by different liquids in these changes varies greatly, but the variation is greatest when they pass through the second phase. Thus 1 lb. of steam at 212° F. if converted into water at 212° F., will give up heat sufficient to raise 996 lb. of water from 60° to 61° F. The heat rendered up by 1 lb. of alcohol vapour at 173° F. during condensation to liquid at 173° F. will heat 374·9 lb. of water from 60° to 61° F. These figures are sufficient to show that a small quantity of steam will boil a large quantity of alcohol. Stills of improved construction depend upon this principle.

The simplest form of distilling apparatus consists of a close vessel connected with a tube immersed in water; the tube is open, and as the vapours expand and pass into the tube, they are cooled down sufficiently to assume the liquid state, their heat being rendered up to the water. It is necessary, then, to have a large body of water to begin with, or else for the water to be continually changed. An ordinary still and worm consists of a boiling vessel with a large head for the accumulation of the bulky vapour, connected with a coiled tube immersed in a tub holding a large body of water, which is continually being changed. The coils of the tube are largest at the upper part of the worm tub, where the vapours are the most bulky. The change of water is effected in this way. A stream of cold water is conducted down to the bottom of the tube, which being there distributed, displaces the water at the top, this latter having condensed, the alcohol vapour has become warm. As the liquid below gradually makes its way upwards, it comes in contact with successive coils of tube, each one being hotter than the other, until the top coil is reached, which is at a temperature differing but little from that at which the liquid is being distilled. The more perfect forms of stills are so designed as to take advantage of the latent heat of the vapours to raise the temperature of the liquid to be distilled.

When a mixture of alcohol and water is distilled, the liquid will not boil constantly at 173° F. until all the alcohol has passed over, but will rise in temperature gradually throughout the distillation until 212° F. has been reached. The distillate, if separated into fractions boiling between fixed points, consists of a series of mixtures of alcohol and water in definite proportions. The mixtures richest in alcohol come over first, that is to say, at the lowest temperature.

The latent heat of the vapour of a liquid with a high boiling point, can be made to boil a liquid with a lower boiling point; for instance, steam at 212° F. can boil alcohol at 173° F., and alcohol at 173° F. in turn can boil ether at 94·8° F. With a simple still, strong alcohol can be obtained from wash by repeated distillation only. Woulfe realised the fact that this wasteful and tedious process could be dispensed with, by connecting together a number of rectifying chambers in such a manner

that the vapour driven off from the chamber nearest the fire should be condensed in the second, and by the heat given out by its condensation, cause the more volatile portions of the liquid of the second to distil into the third chamber, and those of the third into the fourth, and so on, until a sufficient degree of concentration is attained. Adam put this principle of rectification into practice, and it is well illustrated by a description of the working of Laugier's still. In this arrangement another process, that of dephlegmation, is put in operation, which is exactly the reverse of rectification.

It consists in partially cooling the vapours, whereby they are separated into an alcoholic and an aqueous portion; the former passes on to another cooler, only the latter being condensed. Laugier's apparatus consists of separate parts connected by the necessary pipes; these are 1st, a worm tub; 2nd, a dephlegmator; 3rd, a rectifier; 4th, a still. The rectifier is warmed by the waste heat in the flue, the still only is heated by a direct fire. The wash passes first into the worm tub, where it absorbs all the heat given off in the condensation of the alcoholic vapours, thence it passes into the dephlegmator, where it becomes heated to near its boiling point by the condensation of water vapour only; it next passes into the rectifier, where it is boiled by the aid of steam from the still; the alcohol in the steam becoming concentrated in the liquid, is boiled off; finally, the liquid in the rectifier is run into the still, from which vessel it is periodically discharged. The general arrangement is effective in separating the 2 liquids, and the former goes upwards and the latter downwards. It is not adapted to distilling mash of different kinds, nor for yielding alcohol of the highest strength at one operation. The first apparatus to fulfil these conditions was devised by Coffey. Although a variety of apparatus for distilling have been constructed by Savalle, Siemens Brothers, and others, yet some form or modification of Coffey's still is most commonly used in this country. It is constructed largely of wood and sheet copper; the wood being a bad conductor, prevents loss of heat, but it is liable in turn to give rise to leakage, and requires frequent renewal. The wash is raised by a pump to the top of a column, the upper half of which is a condenser, and the lower a dephlegmator; by means of a zigzag copper tube, the wash passes downwards, and upwards again, to the top of a second column, into which it is discharged, where it undergoes a process of distillation, by means of steam rectification, on a series of perforated shelves connected with each other by over-flow pipes. Such stills may be built of any size, even of such dimensions that the pumps of each still are capable of passing 8000 gal. of wash per hour. (Prof. W. N. Hartley.)

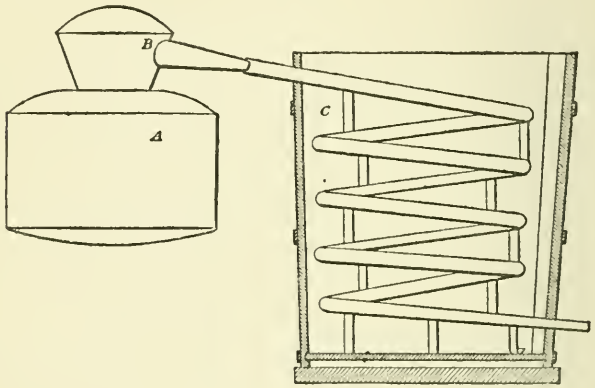
The simplest form of spirit still is shown in Fig. 109, and consists of 2 essential parts, the still or boiler A, which is made of tinned copper, and enters the furnace, and the cooler or worm B, a pipe of block-tin or tinned copper, bent into a spiral and connected with the top of the still. The liquid is boiled in the still, and the vapours passing over are condensed in the pipe, which is placed in a tub or vessel containing cold water. This simple apparatus is not much employed in distilling, as it is impossible to get sufficiently pure products from it on a commercial scale. In an arrangement of this kind, the vapours of alcohol and water are condensed together. But if, instead of filling the cooler with cold water, it be kept at a temperature of 176° F. (80° C.), the greater part of the water will be condensed; but the alcohol, which boils at 172½° F. (78° C.), passes through the coil uncondensed. If, therefore, the water be condensed and collected separately in this manner, and the alcoholic vapours be conducted into another cooler, kept at a temperature below 172½° F. (78° C.), the alcohol will be obtained in a much higher state of concentration than it would be by a process of simple distillation. Supposing, again, that vapours containing but a small

quantity of alcohol are brought into contact with an alcoholic liquid of lower temperature than the vapours themselves, and in very small quantity, the vapour of water will be partly condensed, so that the remainder will be richer in alcohol than it was previously. But the water, in condensing, converts into vapour a portion of the spirit contained in the liquid interposed, so that the uncondensed vapours passing away are still further enriched by this means. Here, then, are the results obtained: the alcoholic vapours are strengthened, firstly, by the removal of a portion of the water wherewith they were mixed; and then by the admixture with them of the vaporised spirit placed in the condenser. By the employment of some such method as this, a very satisfactory yield of spirit may be obtained, both with regard to quality, as it is extremely concentrated, and to the cost of production, since the simple condensation of the water is made use of to convert the spirit into vapour without the necessity of having recourse to fuel. The construction of every variety of distilling apparatus now in use is based upon the above principles.

Adam's apparatus for the production of strong alcohol on an industrial scale is shown in Fig. 110, in which is a still A to contain the liquor. The vapours are conducted by a tube into the egg-shaped vessel B, the tube reaching nearly to the bottom; they then pass out by another tube into a second egg C; then, in some cases, into a third, not shown in the figure, and finally into the worm D. The liquor condensed in the first egg is stronger than that in the still, while that found in the second and third is stronger than either. The spirit which is condensed at the bottom of the worm is of a very high degree of strength. At the bottom of each of the eggs, is a tube connected with the still, by which the concentrated liquors can be run back into it. In the tube, is a stop-cock *a*, by regulating which, enough liquor can be kept in the eggs to cover the lower ends of the entrance pipes, so that the alcoholic vapours are not only deprived of water by the cooling which they undergo in passing through the eggs, but are also mixed with fresh spirit obtained from the vaporisation of the liquid remaining in the bottom of the eggs, in the manner already described.

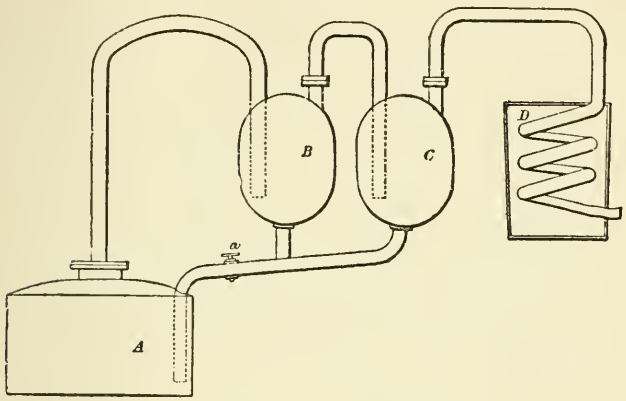
Adam's arrangement fulfils, therefore, the 2 conditions necessary for the production of strong spirit inexpen-

FIG. 109.



sively; but unfortunately it has also serious defects. The temperature of the egg cannot be maintained at a constant standard, and the bubbling of the vapours through the liquor inside creates too high a pressure. It was, however, a source of great profit to its inventor for a long period, although it gave rise to many imitations and improvements of greater or less merit. Among these are the stills of Solimani and Berard, which more nearly resemble those of the present day.

FIG. 110.



Utilising the experience which had been gained by Adam, Solimani, and Berard, and avoiding the defects which these stills presented, Cellier-Blumenthal devised an apparatus which has become the basis of all subsequent improvements; indeed, every successive invention has differed from this arrangement, merely in detail, the general principles being in every case the same. The chief defect in the 3 stills above-mentioned is that they are intermittent, while that of Cellier-Blumenthal is continuous; that is to say, the liquid for distillation is introduced at one end of the arrangement, and the alcoholic products are received continuously, and of a constant degree of concentration, at the other. The saving of time and fuel resulting from the use of this still is enormous. In the case of the previous stills, the fuel consumed amounted to a weight nearly 3 times that of the spirit yielded by it; whereas the Cellier-Blumenthal apparatus reduces the amount to $\frac{1}{4}$ of the weight of alcohol produced. This latter apparatus, however, is adapted only to the needs of large distilleries, and a description of it would be out of place in the present volume.

The operation of distilling is often carried on in the apparatus represented in Fig. 111. It is termed the Patent Simplified Distilling Apparatus; it was originally invented by Corty, but it has since undergone much improvement. A is the body of the still, into which the wash is put; B, the head of the still; *c*, 3 copper plates fitted upon the upper part of the 3 boxes; these are kept cool by a supply of water from the pipe E, which is distributed by means of the pipes G. The least pure portion of the ascending vapours is condensed as it reaches the lowest plate, and falls back, and the next portion as it reaches the second plate, while the purest and lightest vapours pass over the goose-neck, and are condensed in the worm.

The temperature of the plates is regulated by altering the flow of water by means of the cock F. For the purpose of cleaning the apparatus, a jet of steam or water may be introduced at *a*. A gas apparatus is affixed at the screw-joint H, at the lower end of the worm. The part of the apparatus marked I becomes filled soon after the operation has commenced: the end of the other pipe K is immersed in water in the vessel L. The advantage claimed for

FIG. 111.

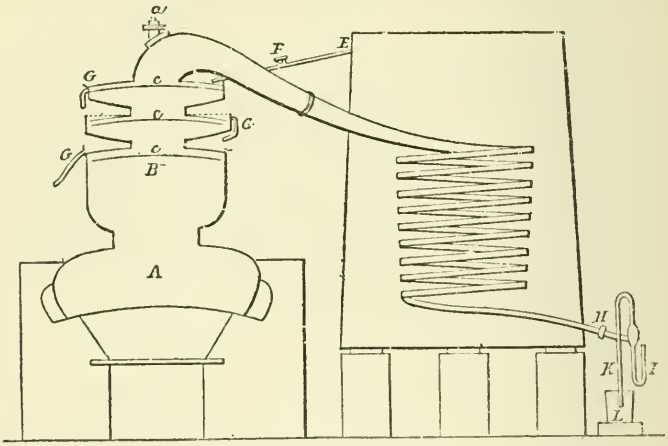
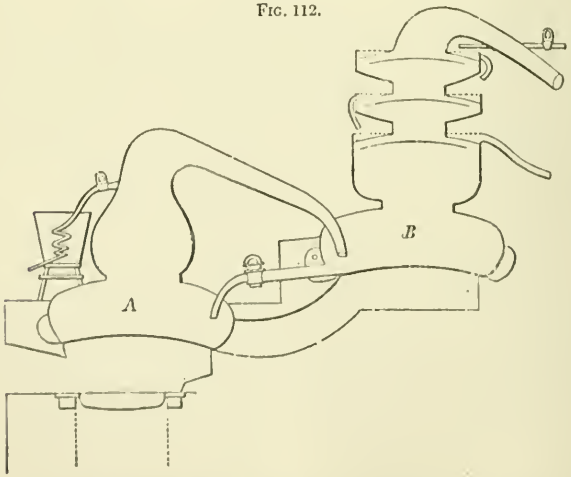


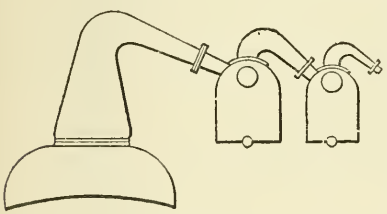
FIG. 112.



this apparatus is that the condensation proceeds in a partial vacuum, and that there is therefore a great saving in fuel. One of these stills, having a capacity of 400 gal., is said to work off 4 or 5 charges during a day of 12 hours, furnishing a spirit 35 per cent. over-proof.

Fig. 112 represents a double still which is largely employed in the colonies. It is simply an addition of the common still A to the patent still B. From time to time the contents of B are run off into A, those of A being drawn off as dunder, the spirit from A passing over into B. Both stills are heated by the same fire; and it is said that much fine spirit can be obtained by their use at the expense of a very inconsiderable amount of fuel. In Jamaica, however, nothing is likely to supersede the common still and double retorts, shown in Fig. 113. It is usually the custom to

FIG. 113.



pass the tube from the second retort through a charger containing wash, by which means the latter is heated previous to being introduced into the still; the tube then proceeds directly to the worm-tank. With an arrangement of this kind, a still holding 1000 gal. should produce 500 gal. of rum (30–40 per cent. over-proof), between the hours of 5 in the morning and 8 in the evening. The first gallon of spirit obtained is termed "low wines," and is used for charging the retorts, each of which contains 15–20 gal. After this, rum of 40–45 per cent. over-proof flows into clean cans or other vessels placed to receive it.

The apparatus used in England for the distillation of grain-spirit is known as "Coffey's" still; and is shown in Fig. 114. It consists of 2 columns, C D E F and G H J K, placed side by side, and above a rectangular chamber, containing a steam-pipe *b* from the boiler A. This chamber is divided into 2 compartments by a horizontal partition, pierced with small holes, and furnished with 4 safety-valves *e*. The column C D E F, called the *analyser*, is divided into 12 small compartments, by means of horizontal partitions similar to the one beneath, also pierced with holes and each provided with 2 little valves *f*. The spirituous vapours passing up this column are led by a pipe to the bottom of the second column or rectifier. This column is also divided into compartments in precisely the same way, except that there are 15 of them, the 10 lowest being separated by the partitions *k*, which are pierced with holes. The remaining 5 partitions are not perforated, but have a wide opening as at *w*, for the passage of the vapours. Between each of these partitions passes one bend of a long zigzag pipe *m*, beginning at the top of the column, winding downwards to the bottom, and finally passing upwards again to the top of the other column, so as to discharge its contents into the highest compartment. The apparatus works in the following way:—The pump Q is set in motion, and the zigzag pipe then fills with the wash or fermented liquor until it runs over at *n'*. The pump is then stopped, and steam is introduced through *b*, passing up through the 2 bottom chambers and the short pipe *z* into the analysing column C D E F, finally reaching the bottom of the other column by means of the pipe *i*. Here it surrounds the coil pipe containing the wash, so that the latter becomes rapidly heated. When several bends of the pipe have become heated, the pump is again set to work, and the hot wash is driven rapidly through the coil and into the analyser at *n'*. Here it takes the course indicated by the arrows, running down from

chamber to chamber until it reaches the bottom; none of the liquor finds its way through the perforations in the various partitions, owing to the pressure of the

As soon as the chamber B′ is nearly full of the spent wash, its contents are run off into the lower compartment by opening a valve in the pipe V. By means of

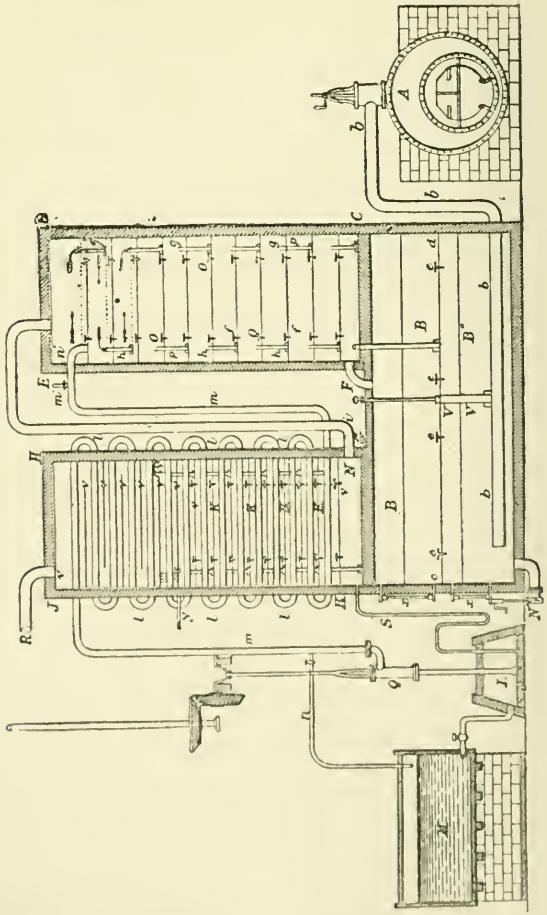


FIG. 114.

ascending steam. In its course downwards the wash is met by the steam, and the whole of the spirit which it contains is thus converted into vapour.

the cock N, they are finally discharged from the apparatus. This process is continued until all the wash has been pumped through.

The course taken by the steam will be readily understood by a glance at the figure. When it has passed through each of the chambers of the analyser, the mixed vapours of water and spirit pass through the pipe *i* into the rectifying column. Ascending again, they heat the coiled pipe *m*, and are partially deprived of aqueous vapours by condensation. Being thus gradually concentrated, by the time they reach the opening at W they consist of nearly pure spirit, and are then condensed by the cool liquid in the pipe falling upon the partition *s*, and being carried away by the pipe *y* to a refrigerator. Any uncondensed gases pass out by the pipe R to the same refrigerator, where they are deprived of any alcohol they may contain. The weak liquor condensed in the different compartments of the rectifier descends in the same manner as the wash descends in the other column; as it always contains a little spirit, it is conveyed by means of the pipe S to the vessel L in order to be pumped once more through the apparatus.

Before the process of distillation commences, it is usual, especially when the common Scotch stills are employed, to add about 1 lb. of soap to the contents of the still for every 100 gal. of wash. This is done in order to prevent the liquid from boiling over, which object is attained in the following way:—The fermented wash always contains small quantities of acetic acid; this acts upon the soap, liberating an oily compound which floats upon the surface. The bubbles of gas as they rise from the body of the liquid are broken by this layer of oil, and hence the violence of the ebullition is considerably checked. Butter is sometimes employed for the same purpose.

When the still contains a charge of about 8000 gal., distillation is carried on as quickly as possible until about 2400 gal. have passed over. This portion possesses but little strength, and is known as "low wines." The remainder of the 8000 gal. is received in another vessel for re-distillation, and the low wines are also re-distilled in another still, until the product acquires an unpleasant taste and smell; these, which are then called "faints," are collected in a vat called the "faints back," mixed with the impure portions of the first distillation, diluted with water, and re-distilled. The product of a further distillation then yields finished spirit.

Fig. 115 represents the apparatus used in Neufchâtel and other places for the manufacture of absinth and similar perfumed spirits. It consists of the following parts:—

A is a kettle enclosed in a wooden jacket, acting as a water-bath enclosing another kettle, which contains the ingredients to be distilled. B is the top or cover of the still; C an opening closed by a plug for charging the still; C′ a similar opening for discharging the plants after distillation. D is the cap of the still, fastened on by a circular collar, and terminating in a neck which conducts the alcoholic vapours to the cooling coil. E is the cooler with its coil, and E′ the discharge pipe of the coil. F is the colourer, furnished, like the still, with plugs through which to fill and empty it. G is a pump fastened firmly to the wall by the collars G′. H is a piston rod; I, the eccentric for driving the pump; J, a pulley on which a band runs to connect with the power; and K, bearings from the pulley shaft. L is a tank or well of metal sunk into the floor. M is a suction pipe, and M′ another, connected with the colourer. N is a 3-way cock attached to the suction pipe to draw any liquid from the tank to deliver it into the still, into the colourer, or to the store-room, or to draw the finished liquor from the colourer, and deliver it to the store-room. N′ is a pipe for drawing off the coloured product; O is a force or delivery pipe; P, a 3-way cock, which directs liquids at pleasure into the still or the colourer; P′, a pipe delivering the liquid into the colourer, and P″ a pipe conveying the liquor into the still. R is a cock and pipe for delivering the manufactured product into the store-room; S, a funnel and pipe to convey the distilled product

to the tank; T. the main steam-pipe connected with the steam boiler; U, the steam-cock for the kettle of the still; and V the steam-cock for the colourer.

water and alcohol in the correct proportion, and the boiler of the still with the ingredients necessary for the preparation of the absinth, the cock P P′ is

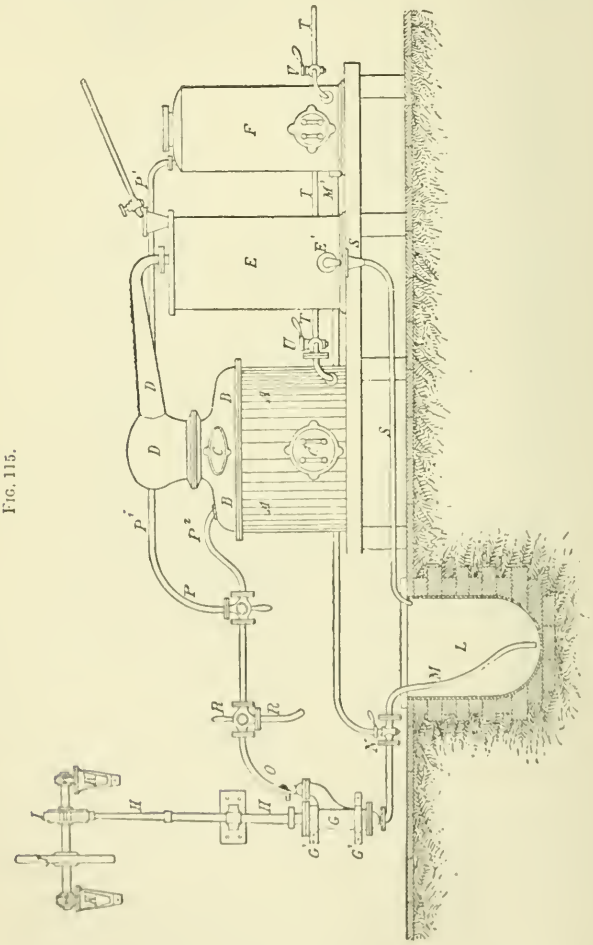


FIG. 115.

The apparatus is worked in the following manner:—

The tank L having been filled with

opened and the pump set to work. The boiler A is immediately filled with the contents of the tank L. As soon as the

tank is empty, the pump is stopped and the cock P closed. Steam is turned on by opening the cock U, and the product soon begins to flow over from the condensing coil into S, and again fills the tank L; it now consists of spirits perfumed by the plants placed in the still; it is white in colour, and possesses already many of the properties peculiar to the manufactured article. In order to colour it, the pump again draws up the liquor into the colourer F, which has been previously filled with the proper quantity of the colouring plants. After this operation, the pump fulfils its third office by raising the coloured absinth from the colourer through the pipe N′, and the cock and pipe R into its final receptacles.

EMULSIFYING.—To emulsify an oil consists in rendering it capable of mixing with water to form a uniform milky fluid, by the aid of an intervening medium, generally saccharine or mucilaginous.

Milk being the most perfect emulsion obtainable, such a mixture of fat which simulates this compound most closely must likewise be regarded as superior in the degree that these qualities are intensified. To be sure, an artificial emulsion always represents a greater percentage of fat than milk, and its preservation is therefore relatively easier than in that obtained from nature, but this fact merely modifies the result, and does not involve the principle. The greater proportion of water in milk also favours decomposition, but, on the other hand, the minute, perhaps even molecular division of the fat globules, renders it possible to withstand decomposition longer than an equally dilute artificial emulsion, wherein the oil globules are not so thoroughly disseminated.

We, of course, recognise the fact that milk contains different animal bodies not present in ordinary artificial emulsions, which are prone to decomposition, so that the similarity drawn between the two is based more upon physical characteristics than their presenting any features in common chemically.

But it is this attempt at compromising its principal physical feature—fluidity—with permanency, which makes the preparation of an emulsion so difficult. To so change a fat as to render it miscible with water is a matter of easy execution, but when we attempt to embody the desirable feature of fluidity, then we are thwarted by physical laws, and resort to chemical means as a compromise.

Condensed milk is a striking illustration wherein by a change of its physical condition, complete preservation has been attained much more satisfactorily than milk in its natural form could be preserved, even with chemical means. It is for this reason that *consistence* is the most desirable feature to ensure the permanence and preservation of any emulsion, natural or artificial.

It is well known that a perfect and permanent emulsion can be made with cod liver oil and malt extract, owing to the consistence of the preparation solely, as we have attempted to use the same agents represented in malt extract, namely—dextrine and glucose, and discovered that as soon as the consistence was abandoned these agents did not possess any advantage over those usually employed for emulsifying fats. To the albumen in milk has been ascribed the high degree of and most permanent emulsification, and therefore gelatine is employed in artificial emulsions, with not much better success however than other agents, when semi-fluid consistence is abandoned.

We will now consider what should be used as emulsifying agents and also such as, while largely used, are not desirable for obvious reasons.

Unfortunately the well-worn maxim, so justly applied to most classes of pharmaceutical preparations, "The sacrifice of medicinal value for elegance," has not been lost sight of in the preparation of emulsions. Periodically, different substances from all the different kingdoms of nature have been proposed, enjoyed a short, fashionable stay, and then been relegated to their well-merited oblivion.

The vegetable gums, acacia and tragacanth, have been the longest in use, and the first mentioned of these has probably answered the purpose of a reliable, convenient, and at least innocuous emulsifying agent better than the majority of latter-day substitutes.

The late Prof. Wm. Proctor announced the proportion to be used of gum acacia to produce a perfect temporary emulsion. His directions were as follows: "Mix intimately in a perfectly dry mortar the oil with one-half its weight of powdered acacia; to this add at once one-half as much water as the combined weight of oil and gum, and triturate briskly until the mixture has assumed the colour and consistence of a thick cream, which produces a crackling noise when the pestle is moved rapidly around the sides of the mortar." This is the emulsion proper, and to this can be added any amount more of water or other desirable vehicle or medicament to bring the finished preparation up to the quantity prescribed.

If perfectly made, this emulsion will stand any degree of dilution with watery mixtures; in fact, its quality is proved when, by a large addition of water, the oil globules will not separate or aggregate at the top of the liquid.

Practice has demonstrated that the proportion of gum can be varied according to the nature of the oil employed, but the constant relation between the water used for the emulsion proper, and the mixture of oil and gum must be scrupulously adhered to as ensuring infallible results.

Fixed oils, rich in gum, *per se*, as copaiba, castor oil, &c., do not require as large an amount of gum as cod liver oil, while in the case of ethereal oils, for instance, oil of turpentine, an equal amount of gum, or weight for weight, is necessary. To prepare an emulsion from turpentine not unfrequently presents difficulties, and so much the more is this to be guarded against, as it is a powerful remedy, and, if presented in a merely mechanical mixture, will prove irritating, and perhaps engender serious consequences.

But then, if by careful observance of this method we can obtain a perfect emulsion, what more is desired? Although this emulsion is perfect it is not permanent, and to circumvent this negative feature is the problem for solution.

While we have not discovered any means or process whereby this problem can be solved, yet we have found agents capable of preventing this separation in a great degree, being guided in their selection by a knowledge of the constituents which are most favourable to this separation, and those that are not.

An emulsion should be palatable, and for this reason it is always sought to make it sweet by the introduction of cane sugar or glycerine. These two agents are the cause of the most dissatisfaction with emulsions. Sugar, owing to its affinity for water, and density, favours separation very rapidly, precipitating while the emulsified oil forms a compact, creamy and gradually diminishing stratum at the top of the vessel. Glycerine, probably from the same causes and its incompatibility with fixed oils, behaves in a similar manner, and for these reasons these otherwise desirable vehicles cannot be represented in an emulsion when permanence is to be obtained.

As no other agents present themselves for fulfilling the sweet object in view, we have been in the habit of preparing emulsions without attempting to make them sweet, and, we believe, without detracting from their palatability, while enhancing their appearance.

Now, then, let us consider what agent will favour the homogeneity of the emulsion, that is, prevent separation or precipitation, bearing in mind that the preparation must not be changed physically or chemically.

Gelatine has been used with some satisfaction, as it retards the separation for a considerable length of time; in fact, it answers the purpose so well that for the extemporaneous preparing of emulsions it leaves nothing to be desired. But in common with other agents used for this purpose, it gradually loses its

power of preserving the homogeneity of an emulsion, and eventually the separation and decomposition, so-called, alluded to above, take place.

The proportion of gelatine employed is about 40 gr. to 1 pint of the emulsion; it should be dissolved in the water and added at any time of the operation. By increasing this amount so that a jelly is formed of the emulsion, a perfectly permanent and stable preparation is obtained. But this result is obtained because the physical character of the emulsion has been changed—fluidity abandoned for consistence. Unhappily we cannot take advantage of this condition, and therefore "consistence is not a jewel" pharmaceutically.

Chemical agents such as change the character of an emulsion by saponifying the oil, have been largely advocated, and to the employment of this class of substances is principally due the elegance and permanence of ready-made emulsions. That this is attained at the sacrifice of the medicinal value of the preparation, we have no doubt, but medical authorities have also demonstrated it to be a questionable procedure to chemically change the constitution of a fat intended for internal administration by what should be a simple pharmaceutical process—emulsification, and now condemn the use of alkalies with balsams and resins. Copaiba is no more exhibited with solution of potash, and alkalies are generally conceded as operating to break up the sensitive electronegative principles of resins, upon which their medicinal value chiefly depends. Animal fat, and especially cod liver oil when rendered alkaline, undoubtedly suffers decomposition in those very constituents to which its superior digestibility is due, and thus what has been gained on one hand is more than lost on the other. The saponification which has been produced by the use of the alkali renders the preparation very prone to rancidity if exposed to the air, and even when freshly made, it possesses inferior palatability, but then this has been of secondary importance to homogeneity or elegant appearance.

But our materia medica is vast in extent, and we have yet another quarter to draw upon, namely, the animal kingdom. It was a rational thought which prompted the employment of egg-yolk as an emulsifying agent, and how well it answers the purpose, we are all familiar with. Egg-yolk unfortunately does not belong to the general armament of a pharmacy, and a convenient and stable form thereof was therefore suggested in the preparation *glyconin*, a mixture of egg-yolk and glycerine in about equal proportions. Although the proportion of glyconin required for emulsifying oil is small, about 1 to 4, and therefore the quantity of glycerine in the finished emulsion not very great, we prefer to use the fresh yolk alone when this can be obtained.

Egg-yolk sometimes possesses advantages as an emulsifying agent over gum acacia when this latter is inadmissible on account of the precipitation that would take place when alcoholic liquids are desired in the combination. The following prescription is typical of the class of preparations in which it will prove a valuable agent:

EMULSION OF COPAIBA AND SPIRIT NITROUS ETHER:

Take of

Copaiba	2 oz.
Oil Almonds, Exp.	4 „
Oils Gaulther. and Sassafras, each	20 m.
Egg-yolk (or Glyconin, 3)	1½ oz.
Water	4 „
Turpentine pitch	1 „
Spirit Nitrous Ether	4 „

Make an emulsion as described under gum acacia. Dissolve the turpentine in the spirit of nitrous ether, and add it to the emulsion.

But it has been reserved to physiological chemistry to discover upon the whole the most rational and valuable of all emulsifying agents. Not valuable in the sense that the preparations are either permanent or homogeneous, but valuable because the emulsification is the most natural, and attained with the

least change only in so far as its superior assimilative qualities are concerned. That preference should be given to such agent in preparing an artificial emulsion as fulfils this mission in the animal or human body we cannot deny, providing it is capable of practical application; that is, if this agent can be obtained in as natural a form as necessary to serve this same purpose artificially. Pancreatine, as is well known, is that peculiar principle which is secreted by the pancreatic gland in animals, performing the function of emulsifying fats so as to prepare them for assimilation in the economy. Modern therapeutists, reasoning that maladies such as indigestion or malassimilation of food, especially of a fatty character, would be benefited by this agent supplied artificially, have had their expectations realised in no small degree, and pancreatine has therefore met with increasing favour. Although believed to be a complex substance, and to possess digestive powers identical with those of pepsine and ptyaline, yet it seems undoubtedly to exercise its greatest power on fats, decomposing them in glycerine and fatty acids, thus fitting them for ready absorption.

Pancreatine has been largely prescribed in substance, but of this we have nothing to say, as our observations are in regard to its pharmaceutical use. The pancreatine obtained from the fresh pancreas of the calf, vulgarly termed sweetbreads, has been most successful in our hands, and we feel confident that as an emulsifying agent it will be found superior to that obtained from the hog or sheep.

Pancreatine possesses greater emulsifying power than any agent we are acquainted with, 1 gr. of this article prepared by the writer having been found sufficient to emulsify 1 oz. of cod liver oil; and by careful manipulation, after having been rendered slightly alkaline by soda, as much as 3 oz. were emulsified, or over 1200 times its weight. An emulsion of this strength is, however, not permanent, and requires the addition of some heavier emulsifying agent in reduced proportion. A pancreatic emulsion, owing probably to its partially decomposed condition, while a desideratum from a therapeutic standpoint, is not so pharmaceutically, unless prepared within a reasonable period of the time when wanted for administration.

As an illustration, we now submit a formula for a somewhat largely used preparation originating in the Bellevue Medical College Hospital, New York:

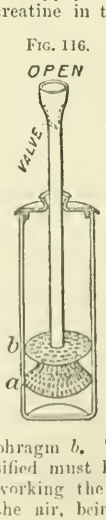
PANCREATIC EMULSION OF COD LIVER OIL AND HYPOPHOSPHITES:

Take of

Cod Liver Oil	8 oz.
Oil Gaultheria	15 m.
Oil Bitter Almonds	10 „
Gum Acacia	2 oz.
Pancreatine, 90 per cent.	15 gr.
Pepsin, U.S.	60 „
Calcium Hypophos	60 „
Sodium	60 „
Water	5 oz.
Spirit Frumenti	1½ „

Mix the oils and gum acacia, dissolve the hypophosphites, pepsine, and pancreatine in the water, make an emulsion to which add the spirit frumenti.

FIG. 116.



In conclusion, we call attention to a simple apparatus for making emulsions in a larger way than can be done economically in a mortar.

Fig. 116 shows an ordinary vessel in which sets a narrow tin cylinder with a valve at the top, fastened with a hinge, a bell-shaped and perforated terminus being attached to the lower end *a*, immediately above which is also a wooden diaphragm *b*. The mixture to be emulsified must half fill the vessel, and by working the cylinder perpendicularly the air, being confined by the valve

closing at the top when the cylinder is plunged downward, is forced all through the mixture, and a perfect emulsion is formed in a very short time. (C. S. Hallberg.)

The successful formation of emulsions, whether of fixed or volatile oils, is dependent upon certain rules, well understood by accomplished pharmacists, which when deviated from will invariably embarrass the operator, either by retarding or completely preventing perfect emulsification. These rules are:—

1. That the water and gum arabic * shall be in definite and absolute proportion to each other. This proportion is 3 parts of water to 2 of gum, both by weight.

2. That the relation of oil to gum (and water) shall be definite within certain limits; that is to say, the mucilage formed in the above proportions is capable of perfectly emulsifying a minimum and a maximum proportion of oil. The minimum proportion is 2 parts of oil to 1 of gum; the maximum proportion is 4 of oil to 1 of gum.

3. That the trituration of the oil, gum and water be continued until a perfect homogeneous, milky white, thick creamy mixture is formed, i. e. until perfect emulsification takes place, before the addition of a further quantity of water or other liquid.

The thick creamy emulsion obtained, if the above conditions are fulfilled, must be the basis of all perfect emulsions. It will bear dilution to any extent with water, forming mixtures varying, according to the proportion added, from the appearance and consistence of cream to that of very thin milk. Obviously the water may be replaced by solutions of saline compounds, syrups, &c., and this permits the production of the various combinations of cod liver oil in current use from the above thick creamy emulsion, which for distinction may be designated as—

* The writer is well aware that other emulsifying agents have been proposed and are used, but he is satisfied that none of these answers as well as does gum arabic.

I. *Concentrated Emulsion of Cod Liver Oil.*—Take of fresh Norwegian cod liver oil, 8 oz.; powdered gum arabic, 2 oz.; distilled water, 3 oz. First weigh the gum into a wedgewood or porcelain mortar, then the oil, and triturate till the gum is well mixed with the oil; then weigh into the mixture the distilled water, and triturate the whole briskly until the mixture thickens and acquires a pasty consistence and milky whiteness. Now scrape down the portions adhering to the sides of the mortar and to the pestle, and continue the trituration for a short time, after which add such other ingredients as may be desirable, or transfer the concentrated emulsion to a wide-mouthed bottle for future use.

This concentrated emulsion will keep for a reasonable time in cold weather, and, if placed in the ice chest, also during warm weather. It may, therefore, be kept in stock if the demand for emulsions is brisk enough to justify it; but inasmuch as its preparation does not consume more than 5 or 10 minutes, it is advised to always prepare it fresh, or at all events, never to prepare more than a week's supply, particularly in summer. Its consistence is such that it is poured out of the containing vessel with difficulty; hence the necessity of using one with a wide mouth, which should be as securely stoppered as possible, and should be cleaned very carefully each time it is refilled. All this takes time and involves trouble, which is prevented by preparing the concentrated emulsion only as required.

II. *Simple Emulsion of Cod Liver Oil.*—Take of concentrated emulsion of cod liver oil, 13 oz.; oil of wintergreen, 24 drops; syrup, 1 fl. oz.; water, 3 fl. oz. Weigh the concentrated emulsion into a mortar, add the oil of wintergreen, and triturate thoroughly; then gradually add first the water and then the syrup.

The manipulation for this emulsion is typical for all the other cod liver oil emulsions given below. It has the consistence of very thick cream, but is

readily poured out of narrow-mouthed bottles, is milky white, and mixes readily with water or other liquids that may be administered with it. It contains exactly 50 per cent. (by volume) of oil, the quantity that manufactured emulsions are said to contain, although some of them do not contain that proportion. The oil of wintergreen disguises the odour of the cod liver oil admirably, and has the further advantage that it acts as a preservative.

III. *Emulsion of Cod Liver Oil with Hypophosphite of Lime.*—This differs from the simple emulsion in that 128 gr. of calcium hypophosphite are dissolved in the water, each tablespoonful of the finished emulsion containing 4 gr. of that salt.

IV. *Emulsion of Cod Liver Oil with Hypophosphite of Lime and Soda.*—This differs from the simple emulsion in that 128 gr. of calcium hypophosphite and 96 gr. of sodium hypophosphite are dissolved in the water, each tablespoonful of the finished emulsion containing 4 gr. of the calcium and 3 gr. of the sodium salt.

V. *Emulsion of Cod Liver Oil with Hypophosphites.*—This differs from the simple emulsion in that 128 gr. of calcium hypophosphite, 96 gr. of sodium hypophosphite, and 64 gr. of potassium hypophosphite are dissolved in the water; each tablespoonful containing 4 gr. of the calcium, 3 gr. of the sodium, and 2 gr. of the potassium salt, and corresponding to a teaspoonful of Churchill's syrup of the hypophosphites.

VI. *Emulsion of Cod Liver Oil with Phosphate of Lime.*—This differs from the simple emulsion in that 256 gr. of calcium phosphate are dissolved in the water by the aid of 128 gr. of hydrochloric acid,* each tablespoonful containing 8 gr. of the phosphate held in pleasantly acid solution.

VII. *Emulsion of Cod Liver Oil with Phosphate of Lime and Soda.*—This differs from the simple emulsion in that 256 gr. of calcium phosphate and 64 gr. of sodium phosphate are dissolved in the water acidulated with 128 gr. of hydrochloric acid; each tablespoonful containing 8 gr. of the calcium and 2 gr. of the sodium salt.

VIII. *Emulsion of Cod Liver Oil with Lactophosphate of Lime.*—This differs from the simple emulsion in that 256 gr. of calcium lactate dissolved in 2 fl. oz. of diluted phosphoric acid are substituted for 2 fl. oz. of the water, each tablespoonful containing 8 gr. of lime lactate or about 10 gr. of lactophosphate.

IX. *Emulsion of Cod Liver Oil with Wild Cherry Bark.*—This differs from the simple emulsion in that the oil of wintergreen is replaced by 8 drops of oil of bitter almonds and in that 1 fl. oz. of the fluid extract of wild cherry bark is substituted for 1 fl. oz. of the water; each tablespoonful containing 15 minims of the fluid extract and one-fourth of a drop of oil of bitter almonds.

Other combinations of cod liver oil with different medicinal agents may be effected in the same way as pointed out in the above, or the proportions of salts may be varied to suit particular cases. The process for the concentrated emulsion also may be applied to the emulsification of other oils, as, for instance, in the following:

X. *Emulsion of Castor Oil.*—Take of castor oil, 4 oz.; powdered gum arabic, 1 oz.; distilled water, 1½ oz.; syrup, cinnamon water, of each 3 fl. oz.; spirit of cinnamon, 12 minims. Emulsify the oil with the gum and distilled water as directed under I., then add the other ingredients successively with constant trituration. This emulsion contains 33 per cent. of castor oil, and is consequently more limpid than the 50 per cent. cod liver oil emulsions above described, and is in every respect an elegant preparation. (C. Lewis Diehl.)

A useful contrivance for making photographers' emulsions is shown in Fig. 117: *a*, funnel with tuft of cotton wool in its throat, serving to filter the inflowing water; *b*, guttapercha bung;

* The use of hydrochloric acid instead of phosphoric acid is preferred, because the large quantity of the latter required would make the preparation unpleasantly sour.

c, jampot provided with a hole to carry a cork, holding an indiarubber tube *d*; *e*, muslin bag retained in position by the bung, and containing the fragments of emulsion.

FIG. 117.

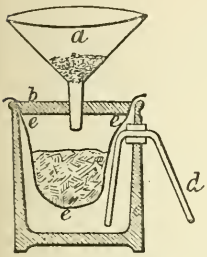
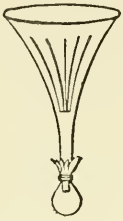


FIG. 118.



Another excellent apparatus for making gelatine emulsions for photographic purposes is that introduced by Birrell, and illustrated in Fig. 118. This apparatus is placed under a tap, the water being allowed to flow in at about the same rate as it will flow through the filtering medium in the funnel. Instead, however, of using cotton-wool for the purpose of filtering the inflow water, it is more convenient to tie a piece of muslin over the stem of the funnel as shown in the subjoined diagram, this method of arranging a filter having been recommended by Colonel Dawson in another case. All string and muslin used should be cleansed before use by boiling in soda and subsequent washing, as recommended in respect to the canvas; and it is undesirable to use either of such materials a second time when one is making a highly sensitive emulsion. The washing being completed, the muslin strainer is removed from the jar, and, the edges being gathered together, the whole is swung round a few times to drive off the loosely held water; but, notwithstanding this, it is extremely probable that the fine shreds of emulsion will have absorbed so much water as to make the preparation inconveniently weak when melted, and the test of this is to weigh the product. A clean beaker of suitable size is balanced on the scale-pan, and a piece of wet muslin corresponding to that used for retaining the emulsion is placed in the weight-pan. The square of muslin containing the emulsion should now be tied up blue-bag fashion, placed in the beaker, and weighed. If it weighs more than 750 *grm.* (26½ oz.), it is well to remove some of the water—a very easy matter if the bag be dipped in alcohol—and moved about for a few minutes, after which it is once more swung round to drive off the redundant water and again weighed.

EVAPORATING.—By evaporation is meant the vaporising of a fluid by means of diminishing the atmospheric pressure, or exposing it to heat or a dry atmosphere; or the heat may be combined either with diminished pressure (boiling *in vacuo*), or with a dry atmosphere. It is resorted to for 2 distinct purposes: (*a*) for the sake of the material from which the vapour is liberated, (*b*) for the sake of the vapour itself. The former class only is to be dealt with here, the latter being chiefly represented by the evaporation of water to produce steam.

Evaporation is essentially a surface operation, hence a leading principle is the exposure of a maximum surface. Another point to be considered is facility for the escape of the vapour generated, preventing its impeding the progress of the operation by pressing on the surface. A third consideration is the avoidance of condensation of the liberated vapour by contact with a cold surrounding medium, either solid or vaporous, so that it can fall back into the mass undergoing evaporation.

The ordinary basis of calculation for evaporating surface is that 10 sq. ft. of heated surface will evaporate 1 lb. of water per minute; and that a thin copper tube exposing 10 ft. of surface will condense about 3 lb. of steam per minute, with a difference of temperature of about 90° F., in other words 30° F. per lb. Hence, steam employed for evaporating purposes should be at 212° + 30° = 242° F.

It has been established that evapora-

tion is the only normal mode of vaporisation of liquids. Gernez has also shown that with all liquids evaporated at temperatures above the boiling point, there is a rate of evaporation which remains constant at every temperature, whatever may be the surrounding temperature, and that the rate of evaporation is sensibly independent of the nature of the medium into which the vapour is disengaged. The duration of evaporation of a column of liquid of determined height, measured when disengaged freely into the atmosphere, and when ignited at the extremity of a tube, proved this; a column of carbon bisulphide, 50 millimetres in height, heated to 90°, discharged itself into the atmosphere in 2 minutes 26 seconds, and in 2 minutes 27 seconds when the vapour was ignited at the end of a tube. In the same tube, containing the same quantity of liquid heated to 100°, the period of evaporation was 1 minute 46 seconds, whether the vapour was ignited or not. The rapidity of evaporation is inversely as the diameter of the tubes in which the evaporation is conducted, as the following numbers show:—

Diameters in millimetres.						
15	5	3	2	1	0·35	0·2
Rate of evaporation.						
1	2·2	2·7	3·6	10	21·90	30·0

In dealing with means of conducting artificial evaporation from a technical point of view, it will be convenient to adopt a classification based on the nature of the article treated and the conditions demanded by it. The chief kinds of liquids subjected to evaporation are:—(1) Saline solutions, for the purpose of recovering their solid contents in crystalline form; (2) syrups, necessitating precautions against organic changes; and (3) acids, with a view of rendering them more highly concentrated.

Saline Solutions.—Sea water may be considered as a dilute saline solution, and its treatment for the recovery of common salt (sodium chloride) affords an example of the utilisation of natural heat (the sun's rays) for evaporation on a commercial scale.

The works in which the sea-salt industry is carried on consist of several series of basins communicating with one another, and possessing extensive evaporating surfaces. Through these, the sea-water is led until arriving in the last, which are very shallow; the already concentrated salt water is allowed to stand till most of the salt has crystallised out. The mother-liquor or "bittern" is drawn off, and the salt is collected and drained to dryness.

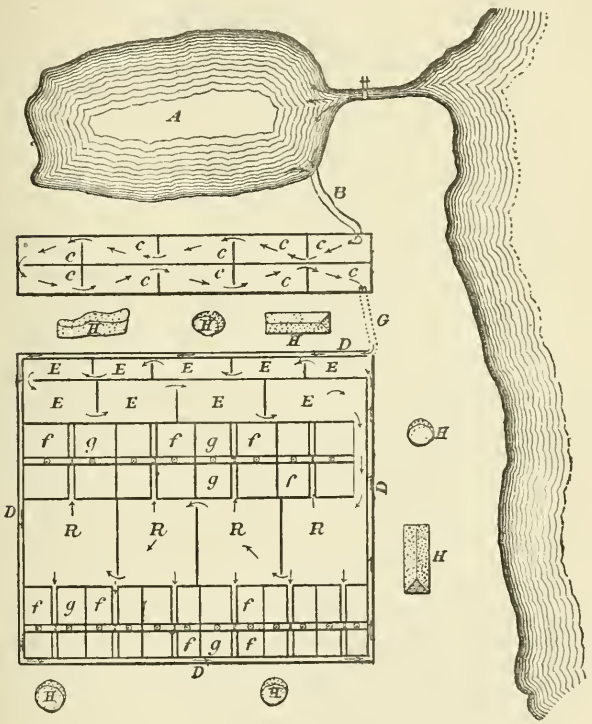
The first of the series of basins is usually a large shallow pond, into which the sea-water is admitted, and where it is allowed to settle, and is stored for use. Sometimes two such large basins are employed, one for settling, the other for storage. Hence the water is carried through a series of other basins, each set in its turn being smaller and shallower. In the last, the salt principally deposits; it is then collected, drained, and stacked for sale.

These works are called by various names, according to the countries in which they are situate. In England, they were known as "salt-marshes," "salterns," "salt-gardens," and by other local names. In France, they are called *marais salants* or *salins*; in Portugal, *marinhas*; in Germany, *Meersalinen* or *Salzgärten*.

Fig. 119 shows a *marais salant* as now in use on the Atlantic coast of France. The spot chosen is generally some little bay or creek protected from the direct action of the waves; from this is led a small canal, through which at spring-tides the sea-water can be conducted into the large reservoir A, the *jas* or *vasière* ("settler") where the water is allowed to clarify. This reservoir is usually placed higher than the rest of the *marais salant*, so that the water can be run off at pleasure into the first set of basins or *couches c*, without pumping. The *jas* may be of any moderate dimensions, and often covers 2¼ acres, the depth varying from a yard to a fathom. The water, having become thoroughly clarified in the *jas*, is allowed to run by

the underground channel B, fitted with a suitable sluice, to the *couches*, which are frequently about 23–24 ft. long, 12 ft. wide, and 1–1½ ft. deep, arranged in sets of 8 or 10 in a double row, as

FIG. 119.



shown, separated by low walls or dams, but communicating with each other in such a manner that the water entering from A by the sluice B can circulate slowly through them, as shown by the lines and arrows, and be drawn off by the sluice G. In fine weather, the water has already undergone some degree of concentration by the time it has settled in the *jas* A, and as it passes in an almost insensible current through the *couches*, it continues to evaporate. It is led by the sluice G into a canal D, which nearly encircles the *marais salant*, and serves to conduct the water on to the *tables* E, arranged similarly to the *couches*; over these, it flows as before in an almost insensible current into other basins R, called *adernes* or *muants*, whence it is fed as required by small channels cut in the soil into the *œuillets f g*, small basins where the salt crystallises.

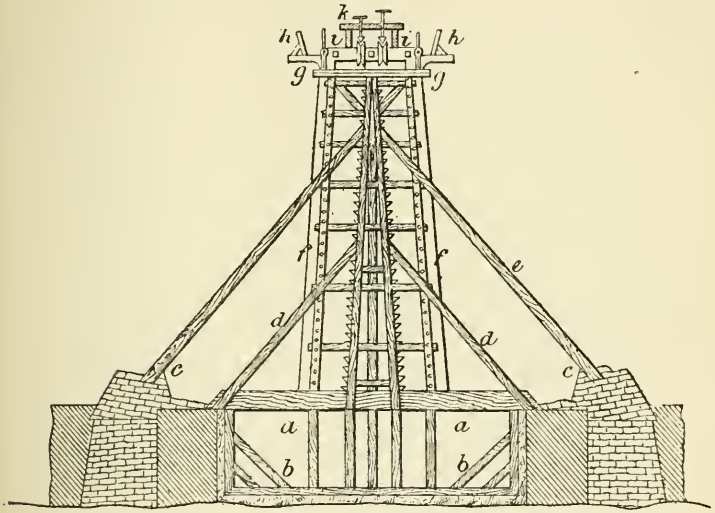
On the shores of the Mediterranean, about Cette, Marseilles, and the Étang de Berre, immense quantities of salt are produced by a somewhat similar arrangement. As, however, there are no tides

in that sea, the arrangement with the separate reservoir A is not essential. A series of basins whose bottoms are levelled and plugged with clay, are made by sets in gradients (usually 3), so arranged with channels and sluices that the water can flow from basin to basin and from one set to another. The general principles involved are much the same as on the Atlantic coast. They differ, however, in the degree of circulation of the water. In the western works, the water is allowed to almost stagnate, as it were, no differences of level being maintained so as to promote its flow, except in respect of the *jas*, which is usually placed on a rather higher level. In the *salins du midi*, on the contrary, when the flowing water has reached its lowest gradient, it is collected in large wells, whence it is drawn up and thrown back by a pump or water-wheel to its former level, and again traverses a like set of gradients, to return once more to another set of wells. The first set are called "wells of green water," the second are called "salt water" wells.

Sometimes brine, whether derived from springs or otherwise, is not brought to the surface at a sufficient degree of concentration to be evaporated by artificial heat, without too great a consumption of fuel. It then becomes necessary to concentrate the brine. The most economical mode of doing this is obviously spontaneous evaporation by exposure to the air; and in places by the seaside where high winds prevail, and where land may be of little value, large quantities of salt are economically produced, as already detailed, by this means. But in other places, this arrangement would be inconvenient, and other means of exposing the liquid to evaporation on an extended surface are resorted to. Such is the so-called "graduation" system invented by Abith in the 16th century, and still practised in a few places on the Continent. A graduation-house (*Gradishaus*) is generally a huge shed, 300–400 yd. long, presenting one end to the prevailing wind, and open at both ends. The interior is filled with rows of fagots; the floor is a large flat reservoir or basin, and on the top, by means of pumps and other arrangements, the water is sprinkled profusely over the fagots, and in course of descending into the trough below, trickles over the sticks, and exposes a large evaporating surface. By several repetitions of this process, the liquor loses water, and a concentrated brine is the result. Fig. 120 represents the general construction of a graduation-house. A description of that at Schönebeck, one of the largest and most important establishments of this kind, will suffice, as the system is not required in England, and is becoming less used elsewhere. The building is 916 yd. long, and 11–14 yd. high. It is filled with a double tier of fagots, presenting a thickness of $5\frac{1}{2}$–$7\frac{1}{2}$ yd. at its base, and $3\frac{1}{4}$–$5\frac{1}{2}$ yd. at the top, consequently offering an immense superficies for evaporation. The illustration shows the whole arrangement in profile, end on. *a* is the large reservoir for the salt water. It is excavated in the ground, and widens out at the top to *c* to catch any drip the wind may carry away; *d e* are merely stays to support the walls of the reservoir, and to sustain the building against the lateral pressure of the wind; *f* is the wooden framework in which may be arranged 4 vertical walls or tiers of fagots. These fagots are made of white- or black-thorn, the branches of which are especially crooked and angular. The water is elevated by pumping to the reservoir *h* at the top, which is so arranged that the outflow can be altered according to the way of the wind. The water is allowed to descend through 2 pipes, closed or opened at will by the valves *k* into the transverse pipe *g*; thence it rises through the pipes, and flows out by cocks into pans, from the overflow of which it drips on to the fagots. Berthier calculates that the average evaporation in ordinary fine weather by this means at Moutiers, in Savoy, where cords are employed instead of faggots, the other general dispositions remaining the same, is $13\frac{1}{2}$ gal. for every sq ft. of cord surface in 24 hours. At Kissingen, the sheds are nearly $1\frac{1}{4}$ miles long by 25 ft. high. The water is raised

6 times in passing from one end to the other of the building, and by this, its strength is raised from 2½ to 17½ per cent. of salinity. Forbes has calculated

Fig. 120.



that here nearly 3 million cub. ft. of water are evaporated annually by this means. The first set of fagots are stained brown by ferric oxide which encrusts them, and they all have to be changed every 2 years or so, on account of a deposit of calcium carbonate ("thornstone") which coats them. By whatever means the strong brine is obtained, it needs evaporation to produce white salt.

Brine evaporating-pans are built of common boiler-plate, ¼–⅜ in. thick, the plates being about 4 ft. long by 2 ft. wide, and well riveted together. The plates are usually of rather smaller dimensions in the part immediately over the fire than elsewhere on the bottom or floor of the pan, as by this means some of the tendency to warp and buckle is supposed to be avoided. In England, the usual dimensions for fine and extra-fine salt-pans are 30 ft. long by 22–25 ft. wide, and 1 ft. 9 in. deep. This gives an evaporating surface of 720–750 sq. ft. Butter-salt pans are perhaps a trifle longer, say 35 ft. by 22–25 ft., and the same depth, with an evaporating surface of 770–875 sq. ft. Common and fishery pans range from 50 to 70 by 22–25 ft., and have the same depth, presenting an evaporating surface of 1100–1750 sq. ft.; some fishery salt-pans belonging to the British Salt Co. at Anderton are 90 ft. by 22, while at Stoke and Winsford, are fishery salt-pans ranging up to 130 ft. in length. Beyond 70 ft. in length, however, there really would not seem to be sufficient gain, at least with the quality of fuel used in Cheshire, to compensate the increased cost of construction and repairs. In France, the common and fishery salt-pans are about the same sizes as ours, only perhaps a trifle wider; and at Dombasle, near Nancy, where Botta has carried the manufacture to as great perfection as is

attained in perhaps any works, the pans (*poêles*) are 72 ft. by 29½ ft. by 43½ in., with an evaporating surface of 2124 sq. ft.

The floor of a pan is usually made slightly arched upwards towards the centre, so that a new pan is rather deeper at its sides than in the middle; but they soon flatten out and warp in various directions under the influence of the firing. On the Continent, cast-iron pans have been in some cases adopted, and cast-iron plates substituted for the smaller wrought-iron ones universally employed in this country in the part of the pan just over the fires. Besides the advantage accruing from the less tendency to buckle and warp, the cast iron has a much higher conductive power than the wrought iron, and the advantage of cheapness. The plates are not made much thicker than the ordinary wrought plates, and are cast with exterior flanges all round their edges, by which they can be bolted together beneath the pan. They also have grooves cast in their edges, to receive asbestos cord or cement, by which, when screwed up, they can be made watertight. Were it not for fear of their greater fragility and some difficulties of adjustment, they would doubtless be employed in this country, thus avoiding leakages into the flues, and the consequent production of large stalactites of salt, technically termed "cats," an intolerable nuisance to the salt-maker. In Austria, such cast-iron pans are actually now in use, and their advantages will be manifest from the following comparative experiments made at Berchtesgaden under like conditions of firing, &c. :—

	Temperature attained in the pan.	Cost of maintenance.	Durability.
		£	years.
Sheet iron	64·4° F.	74·8	12
Cast iron	75·2° F.	34·4	21

It is also sometimes the practice abroad to make the pans with plates riveted on to T-iron bars running across the width of the entire pan, the central flange of the T-iron standing up between the edges of the plates, and these latter having the rivets countersunk into them. This seems somewhat to prevent the buckling.

Wooden pans have been and still are employed. One belonging to Thompson, of Northwich, is 4 ft. 6 in. deep, 12 ft. wide, and 75 ft. long. The 2 ends are of sheet iron, and a long sheet-iron cylinder, closed at the 2 ends by steam-tight doors, runs from end to end. This cylinder is about 18 in. diam., and is supplied from above at about the middle of the pan by means of a lateral pipe with waste steam from an engine and boiler near. By this, the pan is kept at a temperature of about 90°–100° F. This pan is said to produce 45–50 tons of extra fishery salt every 6 weeks or so.

In Cheshire and Worcestershire, the fire-places, usually 4 in number, measure about 4–5 ft. from the door to the back, and are about 3½–4 ft. wide; from the bottom of the pan to the grate-bars is usually about 3 ft. In the case of very long pans, this height may increase to 3 ft. 4–5 in. The grates are formed of square wrought-iron bars, it being found inconvenient in salt-works to employ the improved cast-iron "fish-bellied" bars. This is on account of the great liability to choking with clinkers, and caking of the ashes with the brine which drips from leaks over the fires fusing into clinker, and clogging the grate-bars. The blows necessary to detach these masses would seriously endanger cast-iron bars; but certainly the shape of the bars might well be improved, and rocking-bars, such as those employed in pyrites-kilns and elsewhere, might be more generally introduced with advantage. The firing is usually done in a stoke-hole with steps on each side leading up to the pathway around the pan.

In France, often 2 fires only are put under each pan. The general construction of a French salt-works is rather more regular than in those of this country, and the pans are usually placed side by side in sheds, while a

common flue connects with the outlet-flue of each pan, and such arrangements are made that, when required, any one pan can be cut off by a damper. This common flue is made to pass beneath one or more long deep pans fed with cold brine, and from these the brine is fed, already more or less warmed, into the evaporating-pans. English pans are always set on brickwork, and their bottoms stand about on a level with the ground, overlapping their sustaining walls by some inches, and reposing on longitudinal flues. These latter are usually 4, corresponding in number with the fires, and run straight nearly the whole length of the pan, sometimes entering a chamber at the far end, and passing thence to a low chimney serving one or two pans; but sometimes they converge simply into one common flue, running the whole length of a row of pans, and having an exit to the main chimney. At times the flues do not continue the whole length of the pan, which is then supported here and there by pillars or bits of wall built in parallel lines. Sometimes no flues at all are employed, the pan being merely sustained by pillars of brickwork, sandstone, or cast iron. The whole space then beneath the pan constitutes one large flat flue, through which the heated gases find their way unencumbered. This plan is common in Worcestershire.

On the Continent, other dispositions of flues are often adopted. At Nancy, and pretty well throughout France, the flues from each fire (often only 2) run down to the end of the pan, returning towards the fire-end, and back again once more to the chimney or main flue, each flue thus forming 3 parallel lines. This plan has been tried in England, but is not now usually employed, the simpler form of straight flues leading from each fire right away to the chimney or common flue seeming generally to be preferred. Here in England also they usually have 2 "dead" flues, as they call them, one on each side beneath the pan, these being spaces like flues, but completely walled up at each end, so that no gases can enter them. The flues are usually 2–3 ft. deep, of a capacity in fact to admit a man or boy; and between the entrance of the flues and the fire-place, is built a wall of fire-brick, reaching to within 18 in. of the bottom of the pan. Over this "bridge," as it is called, the heated gases pass before entering the flue, and as the bricks of the bridge become red-hot, they tend to induce a more perfect combustion of the smoke before it enters the flues, where it would become too rapidly cooled by contact with the bottom of the pan, and soot would fall.

In Cheshire, and other places in England, the evaporating-pans are at times employed quite open and exposed to the sky, but nowadays they are mostly surrounded with sheds, these being furnished with ventilating openings in the roof, to facilitate the escape of steam. On the Continent, all except the fine and butter-salt pans are generally covered in with wooden trunks, flat on top with sides converging upwards, thus forming an elongated truncated cone about 5 ft. high over the pan. All along the lower parts of the sloping sides of this cover, and on both flanks of it, are frames fitted with shutters removable by hand. By removing one or other of these, the progress of the crystallisation may be watched. A shelf is sometimes made, running along the whole length of this cover of the pan, just above the shutters; and when the pan is drawn, the workmen fish out the salt with rakes and scoops, and let it drain a bit on the drainers alongside of the pan, corresponding to what our salt-makers call "hurdles," and then pitch it overhead on to this shelf, on which it is allowed to drain pretty completely, the drippings falling back into the pan; thence it is shovelled on to the flat top of the cover of the pan, which is set with tiles. On these tiles, which are kept hot by the steam within the trunk during the time the pan is at work, the salt becomes dried, and is then on a level with the bins (*magasins*) into which it is tipped from wagons for storage. From that end

of the trunk farthest removed from the fires, rises a wooden chimney 10–15 ft. high, for carrying off the steam from each pan; it passes through the roof of the building in which the work is carried on. Sometimes fan-blowers are placed in this and the main chimney, to expedite the exit of the steam. It is asserted by many of the French salt-makers that notwithstanding the greater cost of covering in the pans in this manner, the lessened facility of egress for the steam, the inconvenience, and the somewhat larger amount of labour involved in drawing the pans, they are compensated by a considerable economy in the combustible employed, through the diminished loss of heat by radiation; certainly they obtain cleaner products than English salt-makers. At the Dombasle salt-works, one of the best-managed and best-organised in France, on the contrary, with 100 lb. of the small, poor coal from Saarbruck they only produce 160–170 lb. of common salt. This coal is, however, far inferior to the slack used in Cheshire and Worcestershire, and it is not employed for fine or butter-salt, being unable to maintain a pan in continued ebullition, so small is its heating power. It is used on account of its low price, and its yielding a gentle diffused heat suitable for the work.

Both in England and abroad, attempts have been made to reduce the loss of heat, chiefly due to the scale in the pans and the soot of the flues, by heating by steam. Whatever economy there may be in this method, it has not made much progress among English salt-makers, though the system is a common one for other purposes in the salt districts. The steam-pipes get covered with scale, which is difficult to detach without injury to them, and they are rather in the way of drawing the pans.

So-called "machine-pans" are sometimes employed. They are usually worked in pairs, standing 20–30 ft. apart, with a small engine between, or a shafting running above several of them driven by an engine at one end; this shafting is geared by bevel-wheels to the stirrers, and is so arranged that any one or more of the pans can be thrown into or out of gear at will. The depth of the pans is 2 ft., and an opening is left in one side of each down to the bottom, this opening being closed with outside troughs riveted to the sides of the pans. The bottoms of these troughs go lower than the bottoms of the pans, so that any salt swept out of the openings falls into the troughs, and cannot return into the pans. The pans are fitted with conical covers of sheet iron, through the centre of which pass iron spindles, geared above to the pinions of the shafting by bevel-wheels, and resting on the bottoms of the pans, in which they are free to turn. These spindles are attached at their lower parts to arms or stirrers, carrying scrapers swinging loosely beneath them, and resting on the bottoms of the pans. The covers are fitted steam-tight upon the tops of the pans, and each is provided with one or more manholes, by which workmen can enter to clean the pans. Those parts of each cover corresponding to the parts left open in the sides of the pans are brought down so as to partially close the openings and come just low enough to dip into the brine about 2 in., when the pans are about ¾ filled, while the spindles passing through the covers turn in stuffing-boxes. Thus, when the pans are closed, they are steam-tight, and there is no exit for the steam unless by forcing the water out of the pans into the troughs, or passing off by the flues. Each pan is fired by 3 fires, and boiled as for fine salt, while the spindle carrying the arms and scrapers is made to rotate. The incrustation of the pans is thus for the most part avoided, while very fine salt is produced, and is swept by centrifugal motion into the troughs, whence it is continuously ladled with a scoop, drained on "hurdles," and sent to the stove or the butter-salt bins, as the case may require. The gases from the fires under the pans, and perhaps from the fire of the engine, are made to pass to the flues beneath the outer pans. Both the pans which are heated by the steam stand on

short brick or iron columns without flues; the pans taking the waste gases are set upon winding flues such as already described as being in frequent use in France.

Sometimes an ordinary boiling-pan is mounted with a fishery-salt pan behind it, so that the flues from the former passing beneath the latter, this pan also becomes heated by the waste gases. The Cheshire Amalgamated Salt Co. have some interesting and peculiar composite pans, known as "clay" or "tank" pans, also working on this principle. Fig. 121 represents a ground plan of this arrangement, and Figs. 122, 123, 124, are transverse sections on the lines D E, F G, B C, respectively. The boiling-pan *a* is placed with its upper edge on a level with the ground or barely above it. It is of the usual depth of 1 ft. 9 in., and of the form shown. The fishery-salt pan *b* utilises the waste heat of the furnace-gases, after they leave the flues beneath *a*. There are 3 fire-places *f*, and 3 flues *e*, beneath *a*, together with 2 dead flues. Alongside of and parallel with the pans *a b*, is a pit or trench *c*, about 4 ft. deep, 10–12 ft. wide, and 38–40 ft. long. It is puddled with clay, and lined with bricks throughout the sides and bottom. The upper edges of this trench are about 4–5 in. below the level of the upper edge of the pan *a*. A parting wall of brickwork also divides this trench *c* longitudinally into 2 compartments of equal width. This wall, however, only goes to within about 10 ft. of the end of the trench farthest from the fires, and to within 2 ft. of that end which is in a line with them. The side of the pan *a* turned towards the trench is cut out at the end farthest from the fires, and a shallow channel of sheet iron, just as deep as the pan, connects it with the double trench, while the space *k* contained between *a* and the trench is filled up with a bed of masonry, the surface of which slopes gently from the upper edge of *a* towards *c*, so that the waste brine from any salt drawn on to it may drain into *c*. *k* is connected with *d* by a short wall, and a pump is placed at *h*, while another sheet-iron channel, only 2 ft. wide, but of the same depth as *a*, leads between the pump and the pan *a*. There is a small pit *g*, made of masonry, at the end of this channel; and at the end of the parting wall, at *d*, is a flat space just large enough for a man to stand upon to look after the pump when requisite. With this arrangement, if brine be poured in by the brine-pipe *i*, *c* will be filled, and if the influx of the brine be continued, *a* and *b* may be filled till *c* is nearly overflowing, and *a* becomes full to within 4–5 in. of its upper edge. If then the pump *h* be worked so as to lift the brine from *c* and cause it to fall into *g*, it will flow back into *a*, and, circulating through *a*, will pass again into *c*; thus a steady circulation of the brine may be maintained in the directions shown by the arrows on the ground plan, so long as the pump is kept going. If then the fires *f*, Fig. 124, be lit, the brine will be heated in *a*, and, circulating in the manner described, expose a large evaporating surface. The heat is so managed in these pans as to produce butter-salt in *a* and common salt in *c*; while at *g*, where the pump produces constant agitation, very fine salt is formed. Around the clay pan, the butter-salt pan, and the fishery-salt pan, are the usual paths for the circulation of the workmen, and the places for the so-called "hurdles" *m* upon which the salt is thrown to drain. The stoke-hole is below the level of the ground. The fishery-salt pan *b* may be mounted on columns of brickwork or cast iron without separate flues, and the chimney at the end of this pan carries off the furnace-gases. These pans seem to produce very fine qualities of salt, particularly the common salt from the pit *c*. The yield is about the same (as regards weight of salt to weight of coal consumed) as with the ordinary pans, but the repairs are somewhat less, and certainly the qualities of salt produced are very fine. The chief drawback to them is a rather greater tendency of the pan *a* to become coated with scale, than in

FIG. 121.

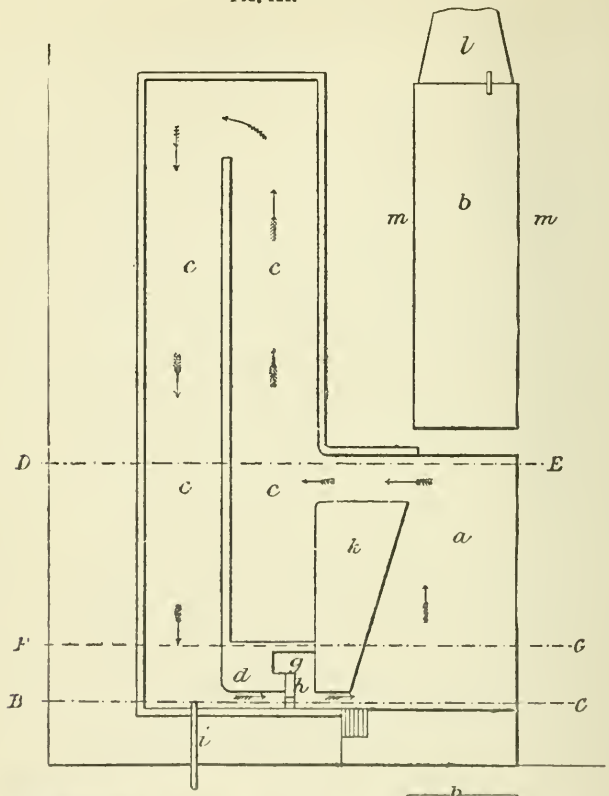


Fig. 122.

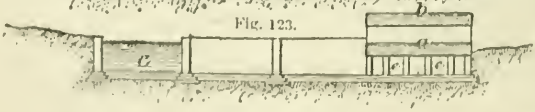


Fig. 123.

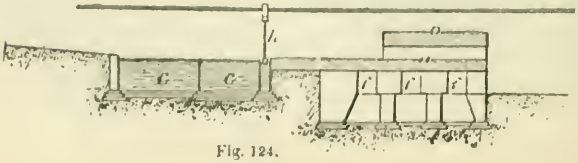


Fig. 124.

the case of the ordinary butter-salt pans.

Otto Pohl's arrangement consists of 2 superimposed pans, at one end of which the fires are placed; the heated gases, passing between them to the chimney at the other end, heat the upper pan from below in the ordinary way, while they sweep the surface of the brine in the lower pan, which thus constitutes the bed of this portion of the flue. Figs. 125 to 130 show this arrangement in ground plan, longitudinal and transverse sections, and in side and end elevations. Milner, of Marston, near Northwich, has a pan mounted on this same principle, which Pohl states to be an adaptation of the principle of the salting-down pans of the alkali-makers. His arrangement, however, differs from that of Pohl in that the upper pan is dispensed with, being replaced by an arch of brickwork. According to Pohl's system of construction, the lower pan is 5 ft. deep. It may be made of boiler-plate or of cast iron, or, for that matter, the bottom and lower parts of its sides might very well be made of elm or pitch-pine, with cast-iron ends and framing. Pohl tried brickwork for the construction of this lower pan, but abandoned it on account of leakage. In the pan figured, however, he has formed the bottom of tiles embedded in clay.

FIG. 125.

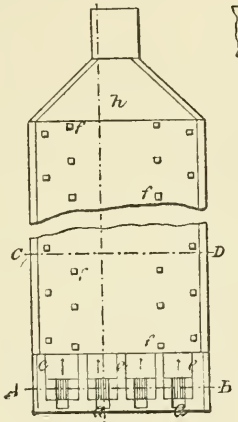


FIG. 129.

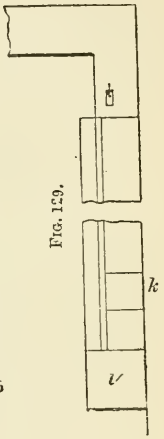


Fig. 130.

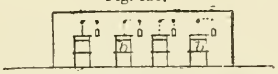
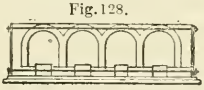


Fig. 128.



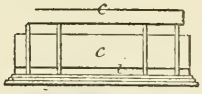


Fig. 127.

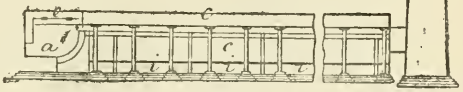


FIG. 126.

Pillars of cast iron rising from the bottom *i* of this lower pan support the upper pan, which is of the ordinary make, and demands no special description. The interval between the two need not, according to Pohl, be more than 3 in. In practice, however, 5–6 in. is not too much from the bottom of the upper pan to the surface of the brine in the lower one when completely filled. The length of these pans is about 60 ft.; breadth of the upper one, about

20 ft., and of the lower one, 22 ft., the space between the two being filled all around with brickwork.

Milner has made the lower pan in his arrangement much wider than this, or rather it may be said a lip or opening running all along each side of the lower pan permits of the salt as it collects being drawn to the sides by rakes, and lifted out by perforated scoops as it accumulates. According to Pohl's arrangement, this might easily be managed by continuing the sides of his upper pan downwards for say 8–9 in., the pan being placed at such a height above the lower pan that these sides may dip 2–3 in. below the surface of the brine in the lower pan, and thus constitute a flue *f* 4–5 in. deep, through which the furnace gases might pass. The lower pan might then be made say 3 ft. wider than the upper one, so as to leave a trough on each side about 18 in. wide, through which the salt might be drawn. As it is, when the pan has to be drawn, which, of course, must be done as soon as it becomes full of salt, the fires have to be let out, the brine run off, and the salt-drawn by the door or manhole *k*.

The furnaces in Otto Pohl's arrangement are 4 in number; they are made about 4 ft. wide internally, and 4½ ft. or even up to 6½ ft. between the top of the arch and the grate-bars; a distance of 3 ft. or so is also left at the back between the end of the grate and the lower pan, the angle being filled up with a curve of masonry as shown at *c*. This form of construction is intended to allow space for more perfect combustion, before the heated gases enter between the pans, where they tend to become rapidly cooled, with proportionate liability to deposit soot. Fig. 130 shows the front elevation and the arrangement of the sliding doors *b*. Pohl at first carried his upper pan right over the fires. He now stops short behind them, covering them in with arches of massive brickwork, so as to avoid as far as may be loss of heat by conduction in this quarter. He also proposed to make a sort of short circuitous flue, through which the products of combustion might be made to pass on their road to the space between the pans, by building 3 arches over the fires, constructed so as to reach alternately to the back and to the front of the fire-place, like the shelves of pyrites-dust kilns. These arches becoming strongly heated would aid in promoting the combustion of the smoke, while they served to catch the dust and ashes carried over from the fires. This plan, however, he appears to have abandoned. A further provision was made for getting rid of soot by keeping the lower pan always filled to the brim, making the end of it farthest removed from the fires a trifle lower than the fire end and sides, and keeping it full to the brim at that end. Much of the soot, falling on the surface of the brine in light flocks, would float thereon, and be carried off over the end of the pan by the draught towards the chimney.

Between that end of the pan and the entrance to the chimney, is a soot-box or closet *h*, with a door for cleaning it out. Notwithstanding all these precautions, large quantities of soot are liable to become condensed, either upon the bottom of the upper pan, or between the 2 pans, and, falling on the surface of the orine, get carried down and mixed with the salt, rendering it black and totally unfit for food. This quality of salt, however, has been found specially suitable for the Hargreaves' salt-cake manufacture, so that the small quantities now produced find a ready enough sale, as the soot does not signify. The method shows an important economy of coal, and, according to Pohl, gives 3 tons of butter-salt with the same amount of fuel and labour as is requisite for producing 2 tons by the old methods. The use of gas from a Siemens producer would obviate the soot completely, while it is probably preferable (according to Milner's plan) to do away altogether with the upper pan, employing merely a brick or tile covering as a reverberatory and radiating surface to throw the heat down into the lower pan, and so get rid of leakages, salt cats, and much cobbling

and repairs involved in working by bottom heat. According to some experiments by Pohl, while the temperature of the upper pan remained suitable for making common salt, or ordinary fishery-salt, that of the surface of the brine in the lower pan was maintained at full boiling, and the produce, so far as grain was concerned, was very fine butter-salt, while no scale worth mentioning forms in the lower pan. He gives as a result of 16 days' boiling with brine containing 25·27 per cent. salt, for 57 tons of slack (from Little Houlton Colliery, Lancashire) burnt,—82 tons of fine butter-salt, and 49 of common salt; while on the old system, the 82 tons butter-salt would have taken 54 tons 13 cwt., and the 49 tons of common salt, 26½ tons, or a total of 81 tons 3 cwt., showing an economy of 24 tons 3 cwt. Instead of the gases escaping into the chimney at a temperature of 600° F. (315° C.) as during the manufacture of salt with the ordinary common salt pans, or at a temperature of 800°–1000° F. (425°–538° C.), as when making butter-salt, they never rose, even with the strongest firing, above 288° F. (142° C.).

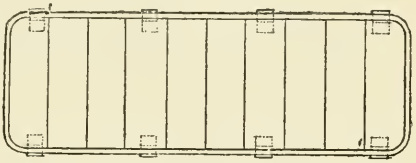
Pohl states that in a subsequent trial, after lifting the top pan at the end nearest the fires to a height of 6 in. and lowering the other end to within 3 in. of the surface of the brine in the bottom pan, he obtained, as an average result of a series of boilings, 3 tons of salt for 1 ton of slack, the gases passing off at a still lower temperature; while in the top pan 200°–208° F. (93°–98° C.) was the temperature attained in front, 180° F. (82° C.) in the middle, and 160° F. (71° C.) at the far end.

The various descriptions of soda pan and setting are shown in Figs. 131 to 136. The apparatus is usually termed a "boat" pan from its shape. It will be noticed that the pan is so set in brickwork that the fire only plays upon the sides about half-way up. Consequently the soda salt, as it crystallises out, accumulates at the bottom of the pan and is then "fished" out up the sloping sides, being protected by the solid brickwork from being burned. An ingenious form of pan has been occasionally tried. It consists of 2 compartments, the one heated and the other kept cool, connected by a large tube. The liquors are kept in constant circulation between the 2 compartments,

Fig. 131.

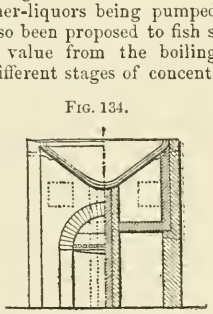
Fig. 132.

Fig. 133.



crystallising out in the cold one, and the mother-liquors being pumped back. It has also been proposed to fish salts of different value from the boiling-down pan at different stages of concentration,

Fig. 134.



leaving the mother-liquors to be finally worked up into a caustic ash. Upon the whole, the method of boiling down by the waste heat passing over the surface of the liquors is the most economical, proper care in the subse-

quent finishing process rendering it perfectly easy to produce a satisfactory carbonate.

Two forms of evaporating pan for lime acetate liquors are shown in Figs. 137, 138. The former is the better, as the salt raked up on the shelving end of the pan shown in Fig. 138 is apt to burn, and the drainings are returned to the pan cold. In some works, the acetate liquor, instead of being allowed to crystallise out in the manner described, is boiled down to dryness in a pot of the form shown in Fig. 139. In this way only an inferior article is obtained; but by evaporating to dryness in a shallow sheet-iron pan, similar to that shown in Fig. 137, a fine product may result.

FIG. 135.

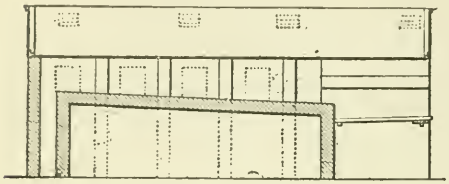


FIG. 136.

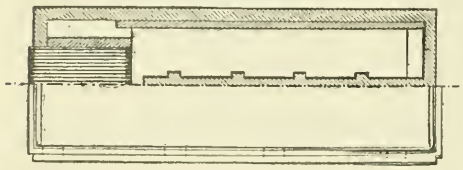
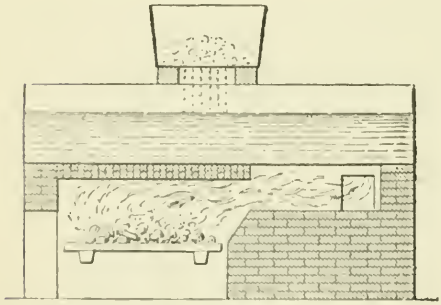


FIG. 137.



Every manufacturer of potash chlorate is aware that his boiling-down pans are acted upon by the liquors, even when they are free from chlorine or hypochlorite. The clear liquid becomes turbid during the evaporation, and in the case of iron pans deposits a red muddy precipitate. In the case of lead, the formation of a mud is not so conspicuous; evidently the lead oxide originally formed decomposes with potassium chloride into caustic potash and lead chloride, at least partially. Usually it is assumed that lead is less acted upon than iron, but the latter is often preferred as being more durable. It seems to be an open question whether cast iron or wrought iron is more suitable for such boiling-down pans; the latter are cheaper for large sizes and more easily repaired than cast-iron pans, but are more quickly acted upon by the liquors.

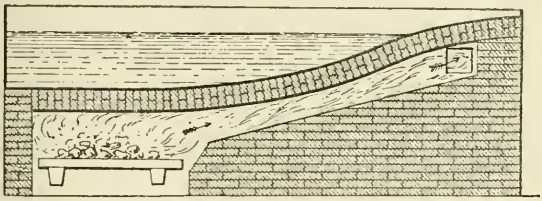
Some experiments made by Dr. Lunge induced him to arrive at the following conclusions:—

1. All metals employed are acted upon by the boiling liquors treated therein, more so by concentrated than by dilute solutions of potassium chlorate, and most of all by the mixed solution of calcium chlorate and chloride formed in manufacturing.

2. The weight of metal dissolved is always smallest in the case of cast iron, by far the greatest in the case of lead, wrought iron holding a middle place, but being not much worse than cast iron. If we consider that the calculations from

the chloride formed are made from pure iron, but that cast iron only contains 90 to 93 per cent. of such, the difference between cast and wrought iron is still further reduced.

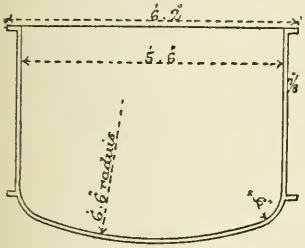
Fig. 138.



3. The weight of chlorate destroyed does not differ very materially whether cast iron or lead is employed.

4. Since in any case the quantity of chlorate destroyed is not essentially less

Fig. 139.



in the case of lead pans than in that of iron pans, but the loss of metal dissolved (as well as the cost of firing and repairs) is much greater with lead than with iron, boiling-down pans made of iron are preferable to leaden ones. According to the practically most important series of experiments, there is no essential difference in respect of action between cast and wrought iron.

Saccharine Liquors. — The means by which heat is applied to the evaporation of saccharine juices and syrups may be described under 4 separate heads, according to their principles: —(*a*) Pans heated by fire, (*b*) pans heated by steam, (*c*) film evaporators, (*d*) vacuum-pans.

Pans heated by Fire.—The earliest and crudest system of evaporation was the "copper wall," or "battery" of open pans called "teaches" (taches, tayches, &c.) The first 2 pans of the series are the clarifiers; thence the juice flows into the teaches, sheet-copper pans set in masonry on a descending plane. As the juice concentrates, each lower pan fills up with liquor from the one immediately above it, until the density of the liquor in the "striking-teach" permits granulation, when the mass is ladled into shallow wooden vessels, and conveyed away to be "cured." By the oldest method, the liquor was ladled throughout the series. More recently an improvement was introduced, consisting of a copper dipper, fitting inside the striking-teach, and having at the bottom a large valve, opening upwards and worked by a lever. The dipper is attached to a crane, which commands the striking-teach and the gutter leading to the coolers. This greatly economises time. The furnace for heating the series is set under the striking-teach; the heat passes by flues to the chimney or to the boiler-flue.

In working a battery, the difficulty is determining the exact moment when the boiling of the "sling" in the striking-teach must cease, i.e. when to make a "skip"; great skill and experience are required to suit each kind of juice.

The drawbacks of the copper-wall are:—(1) Waste of fuel; (2) the amount of labour required and length of time

occupied; (3) considerable waste of liquor in the sloppy manipulation; (4) the proportion of molasses produced is intensified by the churning up of the liquor and consequent admixture of air, and by the irregular and uncontrollable action of the heat upon the surface of the metal with which the liquor is in contact. The temperature prevailing in the striking-teach is not less than 230°–235° F. (110°–113° C.) in any part, and much greater at the bottom of the mass. It is therefore not surprising that liquor showing 10 per cent. of inverted (uncrystallisable) sugar in the first pan, should have 22–23 per cent. by the time it is finished in the striking-teach.

Pans heated by Steam.—The simplest form of steam evaporating-pan consists of a rectangular wrought-iron tank, at the bottom of which is a series of copper steam-pipes, connected by gun-metal bands brazed to them, and carried on wrought-iron supports. The tank is fitted at the side with a steam valve at one end of the steam-pipe range; at the other side is a cast iron-box, fitted with a wrought-iron pipe, for the escape of the condenser water to a condense box. This form of evaporator presents a large heating surface, with facility for cleaning. By passing the ends of the steam-pipe range through stuffing boxes, the pipes can be turned up, and all parts of the interior of the tank be readily cleaned, a matter of great importance.

Under Pressure.—The 5 steam concentrating-pans erected at Aba-el-Wakf receive the juice when it has fallen to a temperature of about 160° F. (71° C.). Each consists of a copper tray, 23 ft. long and 6 ft. wide, heated by a steam-boiler beneath, and covered by a sheet-iron casing which confines the steam evolved from the juice. The steam-boilers work under 60 lb. pressure. The heating surface of each tray is increased by 495 vertical nozzles screwed into it; these are of brass, cast very thin, and slightly tapered. Their mean external diameter is 2⅛ in., and they project 4½ in. above the plate. If the juice is in good order, it makes very little foam: if not properly tempered, a thick froth soon forms, but appears to condense against the cover, and drop back into the boiling fluid. Each particle of juice takes about 18 minutes to pass through the tray, and though exposed to the temperature due to 3–4 lb. pressure of steam on its surface, the syrup gains hardly more colour than would be due to the increased density. The steam generated from the juice is collected into a wrought-iron main, and taken by one branch to the vacuum-pans, and by another to the vacuum-pumps and centrifugal engines, which it actuates, supplying all the power necessary for boiling to grain, curing, and raising the water required throughout the mill. A great drawback to the use of steam from the juice is its low pressure (3–6 lb.).

The advisability of concentrating syrup under pressure in this manner has been the subject of much discussion. It is usually held that any temperature above 140° F. (60° C.) is prejudicial to sugar solutions, and that above 165°–170° F. (74°–77° C.) the proportion of sugar inverted to the uncrystallisable condition is very large. A perfectly white refined sugar exposed to a temperature of 224° F. (107° C.) for 3 hours becomes quite yellow. The normal boiling point of syrup at 15° Tw. (10° B.) is about 214° F. (101° C.). In these pans, the extra pressure of 3–6 lb. of steam means an increase of 8°–16° F. in the temperature in order to arrive at the boiling point, which would seem to be highly injurious. Long exposure, however, is quite as mischievous as high temperature. It is easy to avoid one by incurring the other; the difficulty is to avoid both. Perhaps the chief harm of rapid concentration at a high temperature is the violent ebullition of the mass, whereby portions of heated surface are momentarily left dry. The Aba pans, working with a steam temperature of 290° F. (143° C.) on the under side, and the juice being at 222° F. (105½° C.), actually made less molasses (i. e. inverted and charred sugar) than some more generally-

recognised plans. Still the system cannot be recommended for adoption where there is no necessity for using the water evaporated from the juice.

Film Evaporators.—Under this head are particularly included those evaporators which depend upon the principle of exposing thin films of liquid to the action of a heated surface in the open air. They are generically known as "wetzels" among planters, and comprise the "pans" bearing the names of Gadsden, Wetzel, Schroeder, and Bour, and many modifications, some of which, such as Murdock's, have steam-heated coils. The original form was Aitchison's simple cylinder revolving with partial immersion in the liquid, and heated internally by steam. In its revolution, the cylinder carries on its surface a film of liquor, whose water is soon evaporated. In the Gadsden pan, the cylinder is replaced by a skeleton cylinder, consisting of 2 metallic discs connected by a series of metallic rods fixed at short intervals around the periphery of each disc. Here the drawbacks are the churning of the liquor (except at very low speeds), and the insufficiency of the heat derived from the steam-jacket of the pan.

Schroeder overcomes the churning by having a jacketed pan fitted with a set of revolving solid metallic discs strung upon a square shaft, and fixed about 6 in. apart. The apparatus has the additional advantage of cheapness, but the heat derived from the steam-jacket requires to be supplemented by a coil of steam-pipe winding between the discs, which constitutes an evil.

Bour, observing that larger grains of sugar are produced on the discs in Wetzel's pan than on the pipes, concluded that hollow steam-heated discs would increase the evaporating surface, and produce better grain. A front elevation of his pan is shown in Fig. 140; and vertical and transverse sections of the disc on an enlarged scale in Fig. 141.

Fig. 140.

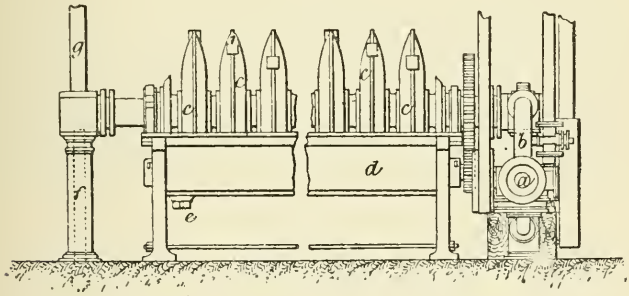
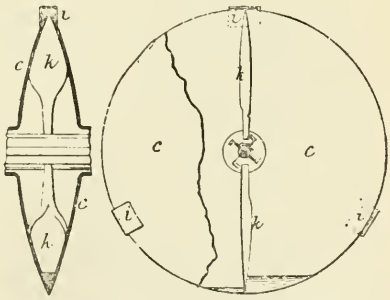


Fig. 141.



a is the steam engine; *b*, exhaust-pipe to heat the revolver; *c*, revolver consisting of 10 copper discs; *d*, copper pan for holding the liquor under treatment, and discharged by the valve *e* at bottom;

f, pipe for carrying off the condensed water from pan; *g*, pipe for carrying of air and uncondensed steam; *h*, safety-valve. The discs are mounted on an axis which allows the steam to communicate freely with them, at the same time collecting the condense-water and carrying it off at one end. Inside each disc are 2 spoons *k*, running from the extreme diameter and terminating in the axis, into which the water is delivered. Outside the discs *e* are small buckets *i*, which lift the liquor as the discs move round, and spread it as a thin film over the surface which is not immersed. The speed of the revolver is 10–20 rev. per minute. Where steam is plentiful, equally good sugar is produced by the quicker speed, and nearly double the work is performed in the same time. One pan cooks 12 cwt. of sugar per hour, from 32½° Tw. (20° B.), as taken from the battery, the temperature never exceeding 170° F. (77° C.). The distributing-cups churn the liquor excessively.

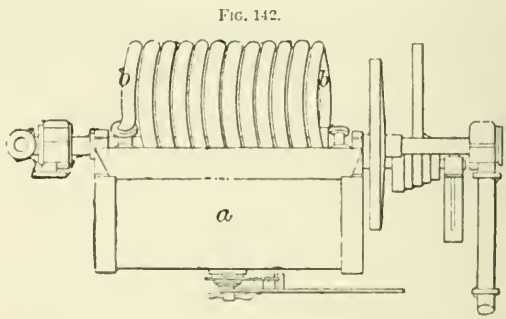
One of the most recent modifications is Pontifex's, shown in Fig. 142. The pad *a* contains the liquor to be evaporated, within which revolves a coil of steam-pipe *b*. Thus a large heating surface is obtained, without the drawback of churning up the liquor.

It is to be observed that all these forms of film evaporator are destined only to finish the concentration begun in the battery. The liquor is brought to them at a density of 44°–46¼° Tw. (26°–27° B.).

Another apparatus on similar principles is Fryer's "concretor," made by Manlove, Alliott, Fryer, & Co., Nottingham and Rouen, shown in Fig. 143. It consists of a series of shallow trays A, placed end to end, and divided transversely by ribs running almost from side to side. At one end of these trays is a furnace B, the flue of which runs beneath them; and at the other end are a boiler C and an air-heater D, which utilise the waste heat from the flue, employing it both to generate steam and to heat air for the revolving cylinder.

The whole series of trays A is placed on a slight incline, the upper end being next the furnace. The topmost 3 trays are made of wrought iron, since the intense heat here would render cast iron liable to fracture. The clarified juice from the pipe M flows first upon the tray nearest the furnace; it runs down the incline towards the air-heater D, meandering from side to side in a shallow stream. Thus it has to traverse a channel 400 ft. long before it can leave the trays at the end adjacent to the air-heater, although the distance between the furnace and the air-heater in a direct line is not quite 50 ft. While flowing over these trays, the juice is kept rapidly boiling by means of the heat from the furnace; and although it only takes 8–10 minutes

FIG. 142.



to traverse, its density is raised from about 15° Tw. (10° B.) to about 52½° Tw. (30° B.).

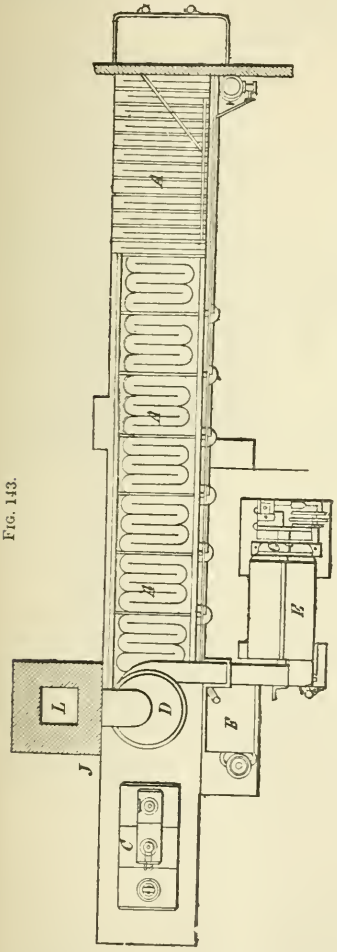


Fig. 113.

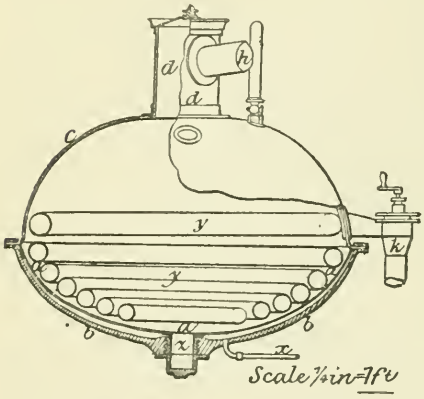
From the trays, the thickened syrup flows into the tank F, and thence passes out into the revolving cylinder E. The cylinder is full of scroll-shaped iron plates, over both sides of which the thickened syrup flows as the cylinder revolves, and thus exposes a very large surface to the action of hot air, which is drawn through it by means of a fan G. Motion is given to the whole apparatus by means of a small engine. In this cylinder, the syrup remains for about 20 minutes, and at the end of that time flows from it at a temperature of about 195°–200° F. (91°–94° C.), and of such a consistency that it sets quite hard on cooling. By the use of dampers, the hot gases from the flue may be directed either under the boiler, returning through it to the heater, or direct to the heater. At J is an auxiliary furnace for raising steam, when the heat from the concretor flue is insufficient or not forthcoming, — as, for instance, when beginning to crush canes, and before the juice has covered the trays. K is a smoke-door for cleaning out the boiler-tubes. L is a chimney, either of brick or iron, for the last escape of the gases.

Vacuum-pans.—The vacuum-pan is shown in section in Fig. 144. The copper pan *a* is fitted in a cast-iron steam-case *b*, with steam-space left between, and is surmounted by a copper dome *c*. The copper and iron pans and the dome are bolted together through their flanges with a wrought-iron ring and bolts so as to be air- and steam-tight throughout. A man-hole *d*, with a ground gun-metal cover, is attached to the top of the dome, from which proceeds the arm-pipe opening into the receiver *h*. A steam-valve *k* opens into the copper steam-worm *y*. This worm gradually diminishes in diameter from the entrance-point at the steam-valve to the exit at the bottom of the pan. A wrought-iron pipe *x* is fitted into the cast-iron pan *b*, to carry off the water from the steam-case; the slide-valve *z* at the bottom of the pan is for discharging the sugar.

Glycerine (introduced here on account of its syrupy nature, though it bears no relation to sugar) is generally concentrated in a modification of the

"Wetzel" evaporating-pan, constructed by Chenaillier, Paris. This *évaporateur universel*, as he terms it, which is very economical and effective, is shown in

FIG. 144.



jacketed trough of the liquid to be evaporated, and when they are revolved, layers of this are brought up and speedily concentrated on their surface. It may also be worked in a vacuum, as shown in Fig. 146.

Acids. — The sulphuric acid made in the chambers is not strong enough for many of the purposes to which it is applied. The acid can be concentrated by boiling, however, which causes the evaporation of a part of the water with which it is combined. This may be performed in leaden pans up to a strength of 1·750 sp. gr.; but the higher the concentration, the greater the difficulty in disengaging the combined water, so that the temperature at which evaporation takes place rises rapidly and an increasing proportion of acid is distilled over at the same time. The acid

FIG. 145.

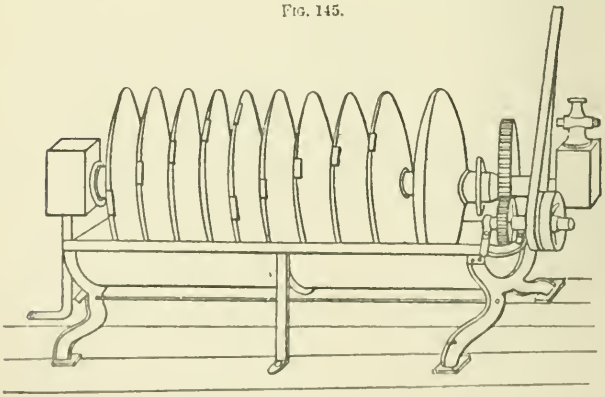
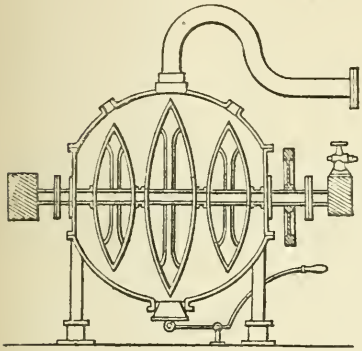


Fig. 145, and consists essentially of pairs of saucers set edge to edge upon a hollow central revolving shaft, through which, steam passes to the interior of the saucers (the waste steam from a high-pressure engine will do); the lower edges of the saucers dip in a

cannot be concentrated to monohydrate by simple evaporation of the water, but moderately strong acid will be distilled, and must be afterwards condensed. As acid of more than 1·750 sp. gr. attacks lead very powerfully, and the boiling point of monohydrated acid is very

nearly equivalent to the melting point of lead, the concentration is not carried beyond that point in leaden vessels, but in retorts of platinum or glass.

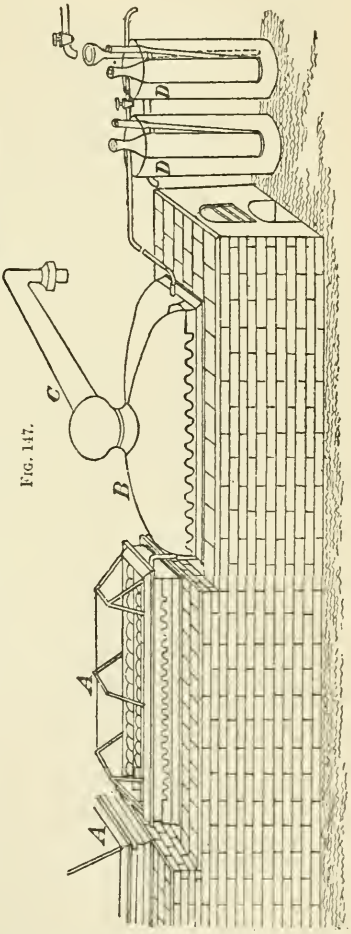
FIG. 146.



When the acid is to be concentrated in platinum vessels, it must first be perfectly purified from nitrogen compounds, as that metal is very rapidly destroyed by them. The most reliable plan of denitrating the sulphuric acid during concentration in leaden pans is by the addition of a small quantity of ammonia sulphate. With tolerably good working, the acid will contain only so much nitrogen compounds that ·1–·5 per cent. of the ammonia salt will suffice.

Fig. 147 shows the most recent form of platinum pan and still, manufactured by Johnson, Matthey, and Co., of Hatton Garden. A are platinum pans, with corrugated bottoms and longitudinal or transverse partitions, exposed to the flame in the flue. They can be worked in series, replacing the thick leaden tanks now employed for concentration of the chamber acid. B is a platinum boiler, with corrugated bottom and partitions to receive the acid at 142° Tw. (60° B.) or above, from the pans A, completing the concentration to 168½° Tw. (66° B.). C is a head and arm for carrying off the vapour to a leaden condenser (not shown) or direct into the chamber for utilisation, if required. D is a flask cooler, to receive the concentrated oil of vitriol from the boilers, and to pass it, cooled, into the carboys; the leaden water-jacket should be so arranged that the cold water may have the greatest possible amount of cooling power.

FIG. 147.



This is the newest form for the concentration of sulphuric acid, securing great strength, productive power, safety and economy in working, and the highest degree of purity of acid, with a minimum of platinum.

By the corrugated form of bottom (Prentice's patent) the greatest possible amount of strength, surface, and consequent evaporating power is obtained in the boiler or still, and a considerable saving in fuel is effected. By means of the pans the large and costly leaden tanks for the previous concentration of the chamber acid, which require constant repair and renewal and more or less contaminate the acid, can be to a great extent done away with. The setting of these boilers and open pans is of the simplest kind: they are placed upon an iron frame over a straight flue, and they may be multiplied or enlarged to any desired capacity of production, without sacrifice of existing plant. Pans of lead (or any suitable material) of the same form or principle, employed for the first concentration of the chamber acid, are included in this patent. The cooler is of an improved economical and convenient form, easy to clean, and securing great cooling power with a minimum of water and space.

Before the adoption of platinum vessels for completing the concentration of the acid, large glass retorts were used, and these are still employed in works where the glass can be bought at a low figure, or where the quantity of sulphuric acid needed in a concentrated state is small, or where the manufacturer has not sufficient capital to afford a platinum still.

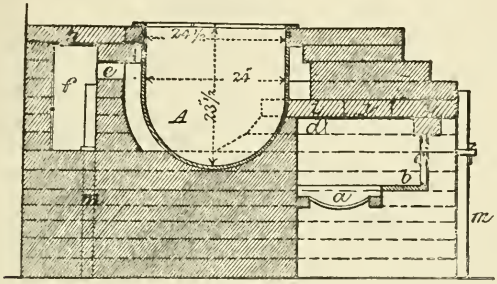
The retorts may be set in two rows in a gallery furnace, and are filled with pure acid at 150° Tw. (62° B.). The number of retorts fed by one fire will depend upon the class of fuel used, as well as the size of the retorts. The retorts are usually protected against sudden changes of temperature by sand baths in iron pots, but other materials have been recently adopted. The jumping of the acid during the boiling is prevented by putting some small pieces of glass, platinum, or gas-retort carbon into the retort. Sometimes a leaden pan is provided underneath the retorts for catching the acid in case of a fracture occurring. The glass of which the retorts are made must be free from alkali, or the acid will attack them rapidly. They are of various dimensions, but those holding about 3 cwt. are most convenient.

The steam evaporated is conducted away by glass arms fitting into the necks of the retorts, and condensed for use. The great drawbacks to glass retorts are that they consume very much more fuel, and that they are constantly liable to accidental breakage, on account of their necessary fragility. The retorts used in this country are cylindrical, about 33 in. high and 20 in. in diameter. Each retort is fired from a separate furnace. The top of the retort is provided with a short wide neck, into which a glass arm is fitted for carrying off the steam. The retorts are filled and emptied by means of leaden siphons, the process being intermittent. It is convenient to allow the acid concentrated during one day to remain in the retorts till the following morning, so that it may cool somewhat during the night.

It will be readily believed that the boiling of such a powerfully corrosive substance as sulphuric acid, requiring a temperature 3 times as great as water, in extremely thin glass flasks holding some 3 cwt. each, is an operation of the greatest delicacy, not to say danger; and it is therefore of primary importance that the "retort house" shall be built of brick or concrete with a most durable roof, and that every crevice shall be securely stopped against the admission of the slightest draught, or drop of fluid, whether rain or acid. The house should also be roomy enough, and especially of a good height, for as ventilation is inadmissible, sufficient space must be left overhead for the accommodation of the extremely pungent and irritating fumes which pour off the retorts during the time that they are being drawn off.

Fig. 148 shows the arrangement and construction of the furnace and the iron pot which holds the glass retort: *A*, cast-iron pot weighing about 4 cwt.; giving it the hollow shape of the bottom of the pot, until the layer of sand is of a uniform thickness of about 1 or 1¼ in., and reaches as far up the pot all round

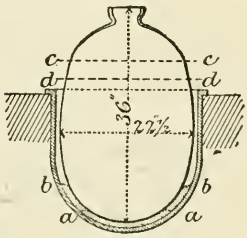
FIG. 148.



a, furnace bars; *b*, bed plate; *c*, door frame; *d*, flue holes, one on each side of the fire-place; *e*, flue holes leading into the main flue *f*. These holes should not be all of the same size, but should increase in proportion as they are farther removed from the flue hole, so that the amount of draught may be equally distributed among the furnaces. The one nearest to the flue hole may be 3 in. by 3 in., the one farthest from it 3 in. by 6 in., and the others of intermediate sizes. *f* is a flue leading to a flue hole, about 12 in. by 9 in., fitted with a damper, and conducting to the chimney. In the figure, the flue hole is supposed to be at the end of 6 retort furnaces, but with 12 retorts it may be placed in the middle. *h*, fire lumps covering in the flue *f*; *i*, fire lumps covering the furnace fire; *k*, thin plates of iron to strengthen the front brickwork, being held in place by *m*, perpendicular tie bars, and *n*, horizontal tie rods.

Before commencing to "set" the retorts, it must first be ascertained that the pots are absolutely dry. Some sand must then be thoroughly desiccated and afterwards sifted through fine wire gauze to free it from any small gravel, &c., that may be in it. Put some of this dried sand into the pot and spread it over the bottom with your hand, as shown at *a* in Fig. 149. Take the retort by its neck with both hands, and lower it gently into the pot till it rests on the bed of sand. Place it as nearly as possible in the centre of the pot, and take care that it stands perpendicularly. Should it be found that the sand does not support the retort (when left alone)

FIG. 149.



in an upright position, a little sand must be poured in between the retort and the pot on whichever side support is wanting. When satisfied that the retort is well placed in the pot, take more sand and pour in all around the glass till it rises as high as *b*. The retort will then be ready for filling with acid to the level *d*, from which point it will rise during boiling to the level *c*.

FILTERING.—In general terms, the object of filtration may be said to be the separation of the solid from the liquid constituents of a fluid mass by means of a straining medium. Either the solid portion, or the liquid portion, or both, may be the valuable ingredient. As different processes and apparatus are employed according to the character of the fluid to be filtered, it will be convenient to divide the subject into several heads.

Water.—Water is undoubtedly the most important fluid submitted to filtration. In this case, the operation is destined to perform 3 distinct functions, at least where the water is required for domestic use; these are (1) to remove suspended impurities, (2) to remove a portion of the impurities in solution, and (3) to destroy and remove low organic bodies.

The first step is efficiently performed by nature, in the case of well and spring water, by subsidence and a long period of filtration through the earth; in the case of river water supplied by the various companies, it is carried out in immense settling ponds and filter beds of sand and gravel. This suffices for water destined for many purposes. The second and third steps are essential for all drinking water, and are the aim of every domestic filter. The construction of water filters may now be discussed according to the nature of the filtering medium.

Gravel and Sand.—The usual plan adopted by the water companies is to build a series of tunnels with bricks without mortar; these are covered with a layer of fine gravel 2 ft. thick, then a stratum of fine gravel and coarse sand, and lastly a layer of 2 ft. of fine sand. The water is first pumped into a reservoir, and after a time, for the subsidence of the coarser impurities, the water flows through the filter beds, which are slightly lower. For the benefit of those desirous of filtering water on a large scale with sand filtering beds, it may be stated that there should be 1½ yd. of filtering area for each 1000 gal. per day. For effective work, the descent of the water should not exceed 6 in. per hour.

This simple means of arresting solid impurities and an appreciable portion of the matters in solution, may be applied on a domestic scale, in the following manner.

Procure an ordinary wooden pail and bore a number of ¼-in. holes all over the bottom. Next prepare a fine muslin bag, a little larger than the bottom of the pail, and about 1 in. in height. The bag is now filled with clean, well washed sand and placed in the pail. Water is next poured in, and the edges of the bag are pressed against the sides of the pail. Such a filter was tested by mixing a dry sienna colour in a gallon of water, and, passing through, the colour was so fine as to be an impalpable powder, rendering the water a deep chocolate colour. On pouring this mixture on to the filter pad and collecting the water, it was found free of all colouring matter. This was a very satisfactory test for such a simple appliance, and the latter cannot be too strongly recommended in cases where a more complicated arrangement cannot be substituted. The finest and cleanest sand is desirable, such as that to be purchased at glass manufactories.

This filter, however, at its best, is but a good strainer, and will only arrest the suspended particles. In a modern filter more perfect work is required, and another effect produced, in order that water containing objectionable matter in solution should be rendered fit for drinking purposes. Many persons when they see a water quite clear imagine that it must be in a good state for drinking. They should remember, however, that many substances which entirely dissolve in water do not diminish its clearness. Hence a clear, bright water may, despite its clearness, be charged with a poison or substances more or less injurious to health; such, for instance, as soluble animal matter.

To make a perfect filter, which should have the double action of arresting the finest suspended matter and removing the matters held in solution, and the

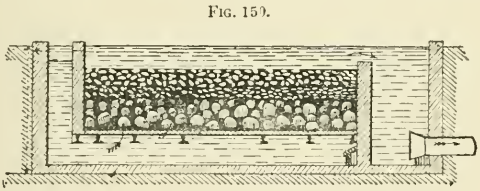
whole to cost but little and capable of being made by any housewife, has long been an object of much attention, and, after many experiments and testing various substances in many combinations, the following plan is suggested as giving very perfect results, and costing only about 8*s*.

Purchase a common galvanised iron pail, which costs 2*s*. Take it to a tin-shop and have a hole cut in the centre of the bottom about $\frac{1}{4}$ in. diameter, and direct the workman to solder around it a piece of tin about $\frac{3}{4}$ in. deep, to form a spout to direct the flow of water downward in a uniform direction. Obtain about 2 qt. of small stones, and, after a good washing, place about 2 in. of these at bottom of pail to form a drain.

On this lay a partition of horse-hair cloth or Canton flannel cut to size of pail. On this spread a layer of animal charcoal, sold by wholesale chemists as boneblack at about 5*d*. a lb. Select this about the size of gunpowder grains, and not in powder. This layer should be 3 or 4 in. A second partition having been placed, add 3 in. of sand, as clean and as fine as possible. Those within reach of glassmakers should purchase the sand there, as it is only with that quality of sand that the best results can be obtained. On this place another partition, and add more fine stones or shingle—say for 2 or 3 in. This serves as a weight to keep the upper partition in place, and completes the filter.

By allowing the filtration to proceed in an upward instead of a downward direction much better results are obtained. For a large supply, as in the case of a paper factory, for instance, a good plan is as shown in Fig. 150. Between the factory supply tank and the river providing the water a longitudinal basin is dug in the ground 30 yd. long, 8 ft. wide, and 8 ft. deep, the sides and bottom being cemented with great care. At the left extremity, which is towards the reservoir, is a well-cemented wall, resting upon iron supports, and bearing a trough connected with the reservoir. At the right extremity, which is towards the river, is a second wall, resting upon the ground, and closing in the basin. Stretching across the basin from side to side a number of iron rails are built into the walls, bearing wooden laths upon which is laid the filter bed. This is composed of 4 layers, the lowest of large stones, the second of coke, the third of flints, and the fourth and uppermost of river sand. The water is allowed to flow gently from the reservoir and enter at the left, that portion of the basin underneath the filter bed. Here it deposits coarse suspended matter, and gradually rising in height penetrates the filter bed from below, and is drawn, filtered, into the factory from the surface of the bed by a pipe built into the lower portion of the wall. For purifying the filter it is simply necessary to allow the current to pass in the opposite direction—that is, the stream is permitted to flow from the reservoir upon the filter bed, which it penetrates and frees from impurities. The settling basin is cleansed by permitting a current of water to flow through it from the reservoir into the river by the lowest opening in the right wall. If such cleansing take place every 3 weeks there will be no need for a renewal of the filter bed

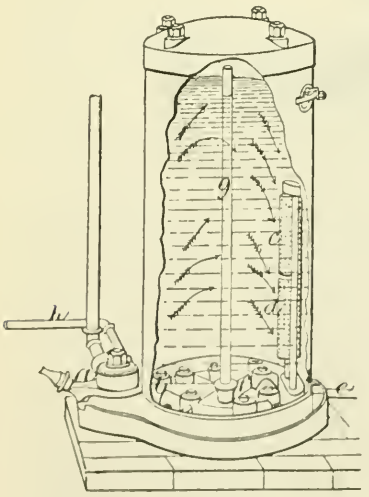
FIG. 150.



except at rare intervals. The velocity of filtration is about 1½ cub. yd. per minute. For the decoloration of peaty water, the addition of 1 part of alum to 8000 of water has been found, in Groningen, an efficient means. The water and the right amount of alum solution are pumped together through a pipe into a clarifying basin, where they remain for 8 hours, and are then passed through a filtering basin, when the residue of suspended matter is given up. Water thus purified remains unaltered in taste, but its hardness and residue, on evaporation, increase by a minute amount.

The application of sand as a filtering medium has received a curious modification in Hyatt's filter. The No. 1 form, shown in Fig. 151, is especially adapted

FIG. 151.



to houses, small steam boilers, laundries, &c., and wherever the quantity of water to be filtered is supplied through a $\frac{5}{8}$-in. pipe under a pressure of 5 or 6 atmospheres, or less. Its operation is as follows: The water is admitted by the compound cock *a*, and passes through the valve *b*, into the sand. The course of the water, during the operation of filtering, is indicated by arrows. A portion of the water passes upward from the valve *b* entirely through the sand by the side of the filter to the top, and then descends to the discharge pipes. Other portions traverse the sand from the side at various heights, between the top and bottom, all escaping through the perforated discharge tubes *c d*. The upward current of water entering from the valve *b*, loosens up the sand and keeps it in a state of mild ebullition for a distance laterally something less than ¼ of the diameter of the filter. The sand is loosened the most and has the greatest motion next to the side of the filter, while farther away it gradually moves slower, and becomes closer as the distance increases from the side, until motion ceases, and the sand compacts together more and more by the pressure of the water passing through. By this plan, in the first part of the filtering operation, the coarsest impurities in the water are retained in a distributed condition by the portion of sand which is in a loosely moving state; the next finer impurities are arrested a little farther away, where, the current of water being slower, the sand is not so much disturbed; finer particles again are stopped farther away by the still denser sand; and so the process goes on by gradations, till the water comes into sand which is motionless and compact. In this compact sand, adjacent to the outlet, the fine and last remaining impurities are obstructed, and pure water passes through the tubes *c d* into the outlet pipe *e*.

This description applies to each of the 3 varieties of Hyatt filters. It permits a larger amount of water to be filtered by a given quantity of sand than is possible where the silt and impurities are permitted to accumulate in a dense stratum upon the motionless surface of a filter bed. At the same time the sand is in condition to be more easily cleansed, the impurities being loosely distributed among the particles of sand

instead of adhering together in a more or less tenacious mass.

The filtering process having thus been explained, the method of cleansing the sand from the accumulated impurities will be described. As a rule the sand in a filter should be thoroughly washed at least once a day, although this depends upon the character and amount of impurities which the water contains. In warm weather, especially, cleansing should be done frequently to prevent decomposition of the organic matter remaining in the sand, which makes filters which are only cleansed at long intervals fountains of filth instead of purity.

In washing Hyatt filter No. 1, the handle of the compound cock *a* is turned to the left as far as it will go. This shuts off the water from the valve *b*, and permits it to enter through the small valves *f*, which are distributed at regular intervals in the bottom of the filter bed. From these valves the water rushes upward through the sand, loosening and carrying with it all the silt and impurities that have been retained in the sand while filtering, and discharging them through the central pipe *g*, from which these issue by one of the openings in the compound cock *a*, into the waste pipe *h*; 5 or 10 minutes for washing is usually quite sufficient. If this be done regularly each day, the filter will be kept in order, and will do its work for a practically indefinite period, as there is no waste of sand, and the filter is constructed of bituminised iron and has no working parts liable to get out of order. After washing, the handle is turned to the right until it stops, and filtering is at once resumed.

Some of these filters are arranged for the introduction of the unfiltered water over the sand instead of at the bottom. It is then filtered downward, and discharged through perforated metal below. In a filter of the form and capacity of house filter No. 1, this arrangement will give finer filtration but a less quantity of water. The plan of washing the sand is, however, as just described.

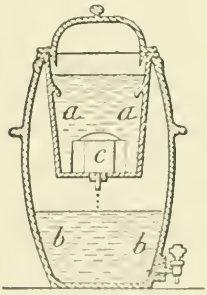
Charcoal, simple.—All kinds of charcoal, but especially animal charcoal, are useful in the construction of filters, and have consequently been much used for that purpose. Charcoal, as is well known, is a powerful decolorising agent, and possesses the property in a remarkable degree of abstracting organic matter, organic colouring principles, and gaseous odours from water and other liquids. It has been shown that it deprives liquids, for example, of their bitter principles, of alkaloids, of resins, and even of metallic salts, so that its usefulness as a medium through which to pass any suspected water is undoubted. The one point to be observed is that it does not retain its purifying power for any great length of time, so that any filter depending upon it for its purifying principle must either be renewed or the power of the charcoal restored from time to time, and this the more frequently in proportion to the amount of impurity present in the water. A combination-filter of sand or gravel and granulated charcoal is a good one; but the physical, or chemico-physical, action of such compound filters, or of the other well-known filter, composed of a solid porous carbon mass, differ in no respect from that of the simple substances composing them; that is to say, such combinations or arrangements are much more a matter of fancy or convenience than of increased efficiency.

Experiments on the filtration of water through animal charcoal were made on the New River Company's supply in the year 1866, and they showed that a large proportion of the organic matter was removed from the water. These experiments were afterwards repeated, in 1870, with Thames water supplied in London, which contains a much larger proportion of organic matter, and in this case also the animal charcoal removed a large proportion of the impurity. In continuing the use of the filter with Thames water, however, it became evident that the polluting matter removed from the water was only stored up in the pores of the charcoal, for, after the lapse of a few months, it developed vast numbers of animalcula, which passed out of the

filter with the water, rendering the latter more impure than it was before filtration. Prof. Frankland reported in 1874 on these experiments as follows: "Myriads of minute worms were developed in the animal charcoal, and passed out with the water, when these filters were used for Thames water, and when the charcoal was not renewed at sufficiently short intervals. The property which animal charcoal possesses in a high degree, of favouring the growth of the low forms of organic life, is a serious drawback to its use as a filtering medium for potable waters. Animal charcoal can only be used with safety for waters of considerable initial purity; and even when so used, it is essential that it should be renovated at frequent intervals, not by mere washing, but by actual ignition in a close vessel. Indeed, sufficiently frequent renovation of the filtering medium is an absolutely essential condition in all filters.

Fig. 152 shows Atkins's filter, in which

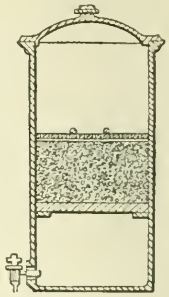
FIG. 152.



a is the unfiltered and *b* the filtered water, *c* being a block of charcoal formed by mixing powdered charcoal with pitch or resin, moulding and calcining. The filter is capable of being taken to pieces and can thus be easily and frequently cleaned. The block should on such occasions be scraped, washed, boiled, and baked.

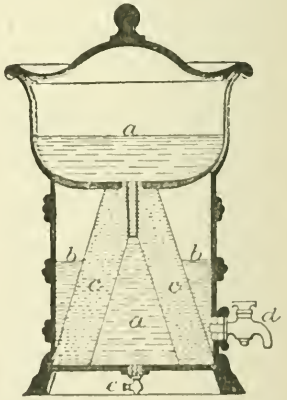
Fig. 153 illustrates another form of Atkins's, in which powdered charcoal is used, retained between movable perforated earthenware plates.

FIG. 153.



Figs. 154, 155, represent Sawyer's filters, in which *a* is unfiltered water; *b*, filtered water; *c*, charcoal hollow

FIG. 154.



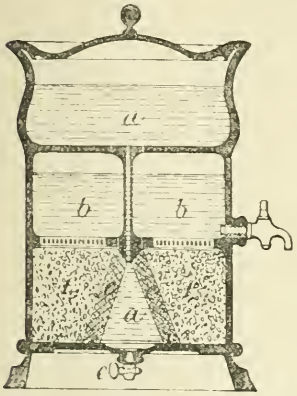
cone; *d*, filtered water tap; *e*, sediment tap; *f*, mass of granular charcoal. The most important feature here is the *upward* filtration.

Charcoal, modified.—Several substances have been proposed for combination with carbon to improve its filtering capacity or increase its germ-destroying powers.

Silicated Carbon.—This was one of

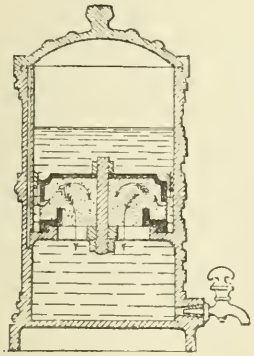
the earliest modifications of the simple carbon block. Figs. 156, 157 show respectively the forms adopted for downward and upward filtration. In the

FIG. 155.



former, the stoneware receptacle is divided into 2 parts by a diaphragm upon which there is fixed, by a porcelain stay, a silicated carbon block,

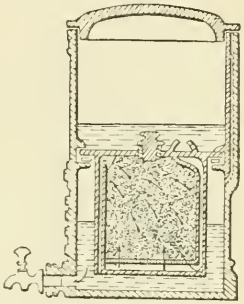
FIG. 156.



which entirely closes the apertures in the diaphragm. The upper surface and corners of the filtering block are non-

porous, consequently the water has to enter at the edges and follow the course indicated by the arrows, before it can reach the clear water compartment be-

FIG. 157.



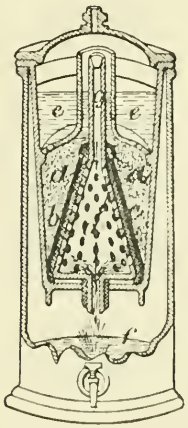
low. In cleaning the filter, it is only necessary to unscrew the nut, when the block can be lifted out and soaked in boiling water, after which the surface can be scrubbed.

The 'Army Medical Report' says of filters employing carbon in porous blocks that, "These are powerful filters at first, but they are apt to clog, and require frequent scraping, especially with impure waters. Water filtered through them and stored, shows signs of the formation of low forms of life, but in a less degree than with the loose charcoal. After a time, the purifying power becomes diminished in a marked degree, and water left in contact with the filtering medium is apt to take up impurity again, though perhaps in a less degree than is the case with the loose charcoal." The advantages of combining silica with the carbon are not at first sight apparent.

Maignen combines charcoal with lime to produce a compound which he calls "carbo-calcis." At the same time he employs an asbestos filtering cloth. The arrangement of his filter is shown in Fig. 158. The hollow, conical, perforated frame *a* is covered with asbestos cloth *b*; *c* is a layer of finely powdered carbo-calcis, deposited automatically by being mixed with the first water poured into

the filter; *d* is granular carbo-calcis filling up the space between *c* and the sides of the containing vessel; *e*, unfiltered water; *f*, filtered water; *g*, tube

FIG. 158.



for admitting air to aërate the water and correct the usually vapid flavour of filtered water. This filter has remarkable power; wine passed through it will come out colourless and tasteless. Moreover the cleansing and renewal of the filtering media are simple in the extreme.

Prof. Bernays, of St. Thomas's Hospital, has taken out a patent for a new filtering material, consisting of charcoal combined with a reduced manganese oxide. The well-known purifying action of charcoal (animal and vegetable), which in its ordinary state is liable to certain difficulties and objections, is in this invention supplemented and improved by heating it in covered crucibles with 5 to 15 per cent. or more of powdered manganese black oxide (the mineral pyrolusite), together with a very small quantity of some fixed oil, resin, or fat. Having ascertained that the simple admixture of the manganese dioxide with the charcoal without previous heating had no utility as a filtering medium, and was even injurious by reason of the diminution of the porosity of the charcoal, Prof. Bernays devised the above method with the object of oxidising the hydrogen and other oxidisable impurities of the charcoal, and hence approximating it to pure carbon in a state similar in efficacy to platinum black rather than in its ordinary less powerful analogy to spongy platinum. The heating is of course out of contact with air, and the temperature sufficiently high to cause the reduction of the manganese dioxide at least to manganous-manganic oxide, which afterwards acts as a carrier of oxygen, and thereby much prolongs the purifying action of the medium. Another method of obtaining charcoal in combination with manganous-manganic oxide is to saturate charcoal with manganous chloride (or even manganese residues) and afterwards subject it to a strong heat in closed crucibles. The charcoal prepared in the above manner may be employed in the filtration of water in layers with sand and other filtering material in the usual manner.

A filtering material which has all the properties of animal charcoal, and is said to give higher results, is magnetic carbide, discovered by Spencer, many years ago, and consists of iron protoxide in chemical combination with carbon. It is considered that the purifying effect is produced by its power of attracting oxygen to its surface without the latter being acted on, the oxygen thus attracted being changed to ozone, by which the organic matter in the water is consumed.

There can be no doubt of the value of this filtering material. Its manufacture is very simple, as it is obtained by roasting hematite iron ore with granulated charcoal for 12 to 16 hours at a dull red heat, and used in a granular form. Another form for making this material is to heat the hematite (iron red oxide) with sawdust in a close vessel. The product is magnetic, and never loses its activity until the pores are choked up. The Southport Water Co. formed their filtering beds of this material, and after years of use it is still giving satisfaction.

Iron.— From experiments made by

allowing water to filter through spongy iron on to meat, it has been found that after 6 weeks the meat remained fresh. Another test was made by preparing a hay infusion, which was kept till it showed abundance of organic life. The infusion was filtered through spongy iron with layers of pyrolusite, sand, and gravel, and then was kept in contact with meat for many weeks. The meat showed no signs of putrescence. In some of the experiments filtered air was supplied, which proves conclusively that bacteria or their germs are not revived when supplied with oxygen after the filtration; this is a result of importance, as it demonstrates that by filtration through spongy iron, putrefaction of organic matter is not only suspended for a time, but that it ceases entirely until reinstated by some putrefactive agent foreign to the water. The peculiar action of spongy iron is believed to be thus explained. If a rod be inserted into a body of spongy iron which has been in contact with water for some time, gas bubbles are seen to escape. These are found to contain carbon and hydrogen, and experiments lead to the conclusion that the carbon is due to the decomposition of organic matter.

The material was introduced for filtration purposes some years ago by Prof. Bischof. His ordinary portable domestic filter consists of an inner, or spongy iron, vessel, resting in an outer case. The latter holds the "prepared sand," the regulator arrangement, and the receptacle for filtered water. The unfiltered water is, in this form of filter, mostly supplied from a bottle, which is inverted into the upper part of the inner vessel. After passing through the body of spongy iron, the water ascends through an overflow pipe. The object of this is to keep the spongy iron, when once wet, constantly under water, as otherwise, if alternately exposed to air and water, it is too rapidly oxidised.

On leaving the inner vessel, the water contains a minute trace of iron in solution, as carbonate or ferrous hydrate, which is separated by the prepared sand underneath. This consists generally of 3 layers, namely, commencing from the top, of pyrolusite (manganese black oxide), sand, and gravel. The former oxidises the protocompounds of iron, rendering them insoluble, when they are mechanically retained by the sand underneath. Pyrolusite also has an oxidising action upon ammonia, converting it more or less into nitric acid.

The regulator arrangement is underneath the perforated bottom, on which the prepared sand rests. It consists of a tin tube, open at the inner, and closed by screw caps at its outer end. The tube is cemented water-tight into the outer case, and a solid partition under the perforated bottom referred to. It is provided with a perforation in its side, which forms the only communication between the upper part of the filter and the receptacle for filtered water. The flow of water is thus controlled by the size of such perforation. Should the perforation become choked, a wire brush may be introduced, after removing the screw cap, and the tube cleaned. Thus, although the user has no access to the perforation allowing of his tampering with it, he has free access for cleaning. Another advantage of the regulator arrangement is that, when first starting a filter, the materials may be rapidly washed without soiling the receptacle for filtered water. This is done by unscrewing the screw cap, when the water passes out through the outer opening of the tube, and not through the lateral perforation.

Various modifications had, of course, to be introduced into the construction of spongy iron filters, to suit a variety of requirements. Thus, when filters are supplied by a ball-cock from a constant supply, or from a cistern of sufficient capacity, the inner vessel is dispensed with, as the ball-cock secures the spongy iron remaining covered with water. This renders filters simpler and cheaper.

As the action of spongy iron is dependent upon its remaining covered with water, whilst the materials which are employed in perhaps all other filters lose their purifying action very soon,

unless they are run dry from time to time, so as to expose them to the air, the former is peculiarly suited for cistern filters.

Cistern filters are frequently constructed with a top screwed on to the filter case, by means of a flange and bolts, a U-shaped pipe passing down from this top to near the bottom of the cistern. This tube sometimes supplies the unfiltered water, or in some filters carries off the filtered water, when upward filtration is employed. This plan is defective, because it practically gives no access to the materials; and unless the top is jointed perfectly tight, the unfiltered water, with upward filtration, may be sucked in through the joint, without passing at all through the materials. This is remedied by loosely surrounding the filter case with a cylindrical mantle of zinc, which is closed at its top and open at the bottom. Supposing the filter case to be covered with water, and the mantle placed over the case, an air valve is then opened in the top of the mantle, when the air escapes, being replaced by water. After screwing the valve on again, the filter is supplied with water by the siphon action taking place between the mantle and filter case and the column of filtered water, which passes down from the bottom of the filter to the lower parts of the building. These filters are supplied with a regulator arrangement on the same principle as ordinary domestic filters. The washing of materials, on starting a filter, is easily accomplished by reversing 2 stop-cocks, one leading to the regulator, the other to a waste pipe.

The use of spongy iron has now been applied on a large scale to the water obtained from the river Nette, for the supply of the city of Antwerp. Dr. Frankland has visited the Antwerp Waterworks at Waelheim, about 15 miles above that city, and reported on the result of his inquiry. He attaches especial value to the fact that spongy iron filtration "is absolutely fatal to *Bacteria* and their germs," and he considers it would be "an invaluable boon to the Metropolis if all water supplied from the Thames and Lea were submitted to this treatment in default of a new supply from unimpeachable sources."

Many preparations of iron have long been known to possess a purifying influence on water containing organic impurities. Thus Scherer, years ago, recommended a solution of iron sulphate where the impurities were present in large quantity. Later still, iron chloride was proposed as suitable, the salt being precipitated in the presence of organic matter as ferric oxide, the oxide thus formed acting also mechanically on the suspended impurities in course of precipitation, very much as white of egg acts in clarifying liquids, when it coagulates and carries impurities with it to the bottom. Other iron preparations have a similar action, notably dialysed iron, while several oxidising agents, such as potash permanganate, are also well known to possess a powerful effect on organic impurities. It will at once be seen, however, that all such substances are inadmissible as filtering media, or purifying agents for potable waters, for the reason, that in the case of some at least of the agents mentioned, decompositions take place, which in themselves might prove dangerous, while in the case of all an excess (and it would be almost impossible to avoid an excess) of the purifying agent would be equally bad, and would render the water quite unfit for domestic purposes. It has been found, however, that various kinds of native rock containing iron protoxide effect the filtration of water very completely, and Spencer, acting on this idea, after experimenting, found that when the iron protoxide was isolated as magnetic oxide, it both freed the water from turbidity and effected decoloration very quickly. Thus bog-water, as dark as porter, when filtered through it speedily lost its colour and became clear and sweet, the carbonic acid given off during the process of decomposition rather tending to improve the water. The purifying power

of the magnetic oxide does not deteriorate with use. The oxide gets coated with a slimy deposit, owing to the deposition of decomposed organic matter, but this being removed, it is as powerful as ever in its purifying action. Unfortunately this iron rock is not found native to any extent, but the fact of its action being determined, Spencer continued his experiments with the result that it can now be produced artificially, and forms one of the most efficient and useful filters for domestic purposes.

Metallic iron is employed by Jennings & Hinde. The filtering material consists of fine iron or steel shavings, filings, turnings, or borings obtained from the swarf or skin of cast iron, wrought iron, or steel; this material may either be used by itself, or it may be used with other materials, either mixed with them or in separate layers. The iron or steel shavings, &c., are obtained from iron or steel that has been brought to a state of fusion either by melting or the processes necessary for making cast iron, wrought iron, or steel, and being separated from many of the impurities contained in the ore from which it was obtained, will have but a comparatively small portion of earthy impurities mixed with it, and will be for this reason superior to iron which is obtained from native ores or oxides without fusion.

By filtering water through small divided swarf or skin of cast iron, wrought iron, or steel, free oxygen will be withdrawn from the water, and consequently any insects or animalcula contained in the water will be deprived of life, and any germs contained in the water will be deprived of the oxygen necessary for their development and life, and the water will be consequently purified and rendered wholesome. A convenient way of forming a filter is to use a layer of the turnings, shavings, &c., together with layers of other filtering material resting upon a perforated partition placed across a closed vessel. The materials are cleaned by boiling them in hot water with a small quantity of ordinary washing soda, to remove any oil or grease that might accidentally be associated with the materials above mentioned. Afterwards the iron borings should be well washed before being put into the filter. The filter vessel may be of any ordinary construction and shape. If sand is used in conjunction with the above-mentioned materials it is preferable to place some of the sand at the bottom of the filtering vessel, and the iron or steel materials, or both, over the sand, and then more sand over them. These materials are disposed so that they may be partially separated from each other by perforated plates of earthenware, glass, or other suitable material. But this partial separation, though convenient, is not essential, as the perforated plates may be dispensed with and the material placed over and under each other in layers without plates to separate them.

Magnesia.—One object of filtration is the removal of salts in solution, notably lime, which renders water "hard."

In some of the dyeing establishments in Germany water containing lime has been softened successfully by a new process. The principle of the invention is based on the fact that magnesia oxide made red hot easily absorbs, after hydration, the free carbonic acid of natural water, and by thus depriving the water of the gas dissolved in it causes the lime carbonate in solution to be precipitated. The magnesia itself is then dissolved, and joins the magnesia bicarbonate which is in the water. At first the water cleaned in this way was blamed for attacking old boilers which were fed with it, and filling them with mud. It was, however, found that magnesia sulphate in the pure water, when heated to a high degree, acted upon the lime carbonate, of which the deposit in the boilers consisted, and formed gypsum and magnesia oxide, so that the hard deposit was gradually transformed into mud. When this was blown off it not unfrequently happened that weak parts in the plates were exposed which previously were kept tight

by the deposit, and this gave rise to the opinion that the plates were attacked.

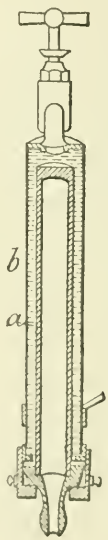
How erroneous this supposition was is clear from the fact that the always present magnesia hydrate is alkaline, and counteracts the effects of acid, which would act corrosively. At first, stirring was considered indispensable, but it was found that by taking an excess of a mixture of magnesia hydrate, with a proper substratum serving as a filtering medium through which the water could pass continuously, the desired effect was obtained without any trouble. When proportionate quantities of finely powdered magnesia oxide and sawdust are mixed with water it will be found that, under the action of heat, magnesia hydrate is formed throughout the whole mass. After cooling, the magnesia hydrate will be discovered so firmly united with the sawdust, so to speak crystallised into it, that it cannot be removed by mechanical means.

This preparation thus possesses the quality of filtering water in a high degree. By tightly filling cylinders of metal with this mixture, and forcing dirty water through, the water, it is said, leaves the first cylinder not only deprived of all lime, but quite clear, the lime carbonate crystallising directly upon the sawdust. The action is so rapid that even water saturated to the fullest extent with lime or gypsum leaves the apparatus with these substances perfectly removed, after 10 minutes' action.

Porous Pottery.—Chamberland has found that the liquid in which microbes have been cultivated becomes absolutely pure if passed through unglazed porcelain. Its purity can be demonstrated by mixing it with liquids sensitive to the action of microbes, such as veal broth, milk, and blood, in which it produces no alteration.

A tube *a* (Fig. 159) of unglazed porcelain is enclosed in another *b* of metal, and the water to be filtered is admitted to the space between the two by turning a stop-cock. Thence it slowly filters through to the inside of the porcelain tube, and flows out at the bottom. Under a pressure of 2 atmospheres, or 30 lb. to the sq. in., a tube 8 in. in length, with a diameter of 1 in., will yield about 5 gal. of water daily.

FIG. 159.



For a larger supply, it is only necessary to increase the size or the number of the tubes.

In cleansing the filter, the porcelain tube is removed, and the microbes and other matter that have accumulated on the outer face of it are brushed off. The tube may also be plunged in boiling water, in order to destroy any germs that may be supposed to have penetrated beneath its surface; or it may be heated in a gas jet or in a furnace. In fact, it can be more readily and more thoroughly cleaned than most of the domestic filters in ordinary use.

It is interesting to remark that some of the earliest filtering vessels of which we have any knowledge are simply made of porous earthenware. After all our modern researches after antiseptic filtering media, we are reverting to the ways of our remotest forefathers.

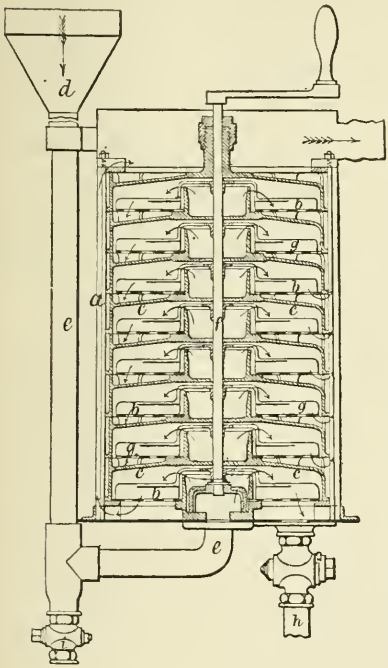
Cellulose.—One familiar form of cellulose as a filtering agent is that of the ordinary laboratory filter-paper. The same may be used on a larger scale by mashing it into a pulp with the liquid to be filtered, and allowing it to deposit on a filter cloth automatically, as in the filters made by Maignen for industrial purposes.

This or a similar material is employed by Piefke at the Berlin Waterworks.

The filter shown in Fig. 160 consists of a wrought-iron casing *a* containing a number of perforated brags *b*, which form the bottom of flat bell-shaped cast-iron vessels *c*, the whole grouped one above the other inside the casing. The

water to be filtered enters by the funnel *d*, and through pipe *e*, runs into the vessels, overflowing in the direction of the arrows, and after passing through the filtering material spread upon the perforated brags *b*, rises till it overflows at the outlet. The filtering medium is chemically prepared cellulose or vegetable fibre, and is variously treated according to the purpose for which the filtered water is to be used, or, in other words, according to the degree of purity required in the filtered water. Its price varies accordingly; the best quality is charged at 75*s.* per cwt., and a filter capable of purifying 1000 gal. of water per hour requires, for its first charge, about 3 lb. of filtering material. To charge the apparatus the fibre is mixed with water to a thin paste and admitted through the funnel, when it deposits in an even layer over the perforated surfaces *b*, and the filter is then quite ready for action. After about 1200 gal. of water have been purified per square foot of filtering area, the latter requires cleaning or washing out; this is performed in a very simple manner by charging the filter with water in the usual manner, and at the same time slowly rotating the vertical spindle *f*, which carries the scrapers *g*, and by means of which the filtering material is suspended in the water, the latter washing out the impurities. As soon as the water runs clear again, the rotary action is stopped and the tap *h*, on the bottom of the casing, is opened to allow the water to run off, and the filtering material to settle, when the filter is again ready for use. The quantity of water which may be filtered before it becomes necessary to clean the fibre depends, of course, largely on its state of impurity, and it is advisable to use as a guide the pressure required to force the water through the filter. This should not exceed 3–4 ft. of water pressure, and it is therefore best to place the funnel about that height above the overflow. At each cleaning a small quantity of filtering material is naturally washed away with the impurities; this amounts to about 10 per cent., which quantity should be replaced by admitting it with the water. For the purpose of washing out the filter it is not necessary to use filtered water, nor is water of any particular pressure required; it may be simply charged through the delivery pipe. If at any time it becomes desirable to entirely empty the filter of the filtering material, water is charged through the delivery pipe or into the open vessel, and the tap *i*, at the bottom of the supply pipe *d*, is opened, when the fibre will run out with the water.

FIG. 160.



The apparatus can be recharged as described above, and for the complete operation of cleaning one filter, one man only is required for about 10 minutes. The filter is recommended by the manufacturers for purifying water for all purposes; a small size measuring only 9 in. in diameter and 15 in. high inside, and carrying only about 1 oz. of filtering material, is specially manufactured as a portable filter for military purposes, capable of filtering over 80 gal. of water per hour.

Sponge.—The problem of constructing a filter for steam users and manufacturers that should be able to deal with large quantities of muddy river and canal water, and should at the same time be capable of being easily and efficiently cleaned, has been solved by the adoption of an elastic filtering material, which when compressed forms a compact bed through which the water percolates, but when released immediately expands, freeing itself from the accumulated dirt, and offering little resistance to the flushing current that is then sent through it in the opposite direction. The material employed is sponge contained in a cylinder, and normally compressed between the cylinder end and a piston. While the cleansing operation is being conducted, the piston is alternately raised and lowered, the action on the filtering medium being similar to that ordinarily adopted in washing a soapy sponge; it is first allowed to absorb water until the pores are filled, and then the water is squeezed out, carrying a part of the mud with it, the process being continued until the effluent water is clear.

A successful installation of these filters is in operation at the works of Garton, Hill & Co., saccharum manufacturers, Battersea, London, where it is supplying feed water for 8 boilers, each 30 ft. by 7 ft. When the river is particularly muddy, the effluent water from the filter is bright and clear, and as far as appearance goes, is similar to the company's water, which is also drawn from the Thames, though of course at a higher part of the river, and has been submitted to an elaborate process of settling, and filtration by sand beds. The immense quantity of mud eliminated by the filter is made manifest as soon as the cleaning process is commenced, when it pours out in a thick stream, gradually becoming clearer and clearer until the turbidity ceases. It is not contended that sponge has any power to extract the soluble impurities contained in water, or to counteract the ill effects of contamination by sewage. All that is claimed for the filter is that it will rapidly cleanse large quantities of muddy water sufficiently for every manufacturing purpose, and for feeding boilers both on shore and in river boats, and that with a very small amount of care it will remain in good working order for years. The filters are made in 5 sizes, the smallest of which will pass 100–150 gal. per hour, and the largest 2000–3800 gal.

Filtering Cisterns.—The following is a description of a filter which purifies foul water from organic impurities held in solution as well as from suspended solids. Take any suitable vessel with a perforated false bottom, and cover it with a layer of animal charcoal, on the top of that spread a layer of iron filings, borings, or turnings, the finer the better, mixed with charcoal dust; on the top of the filings place a layer of fine clean siliceous sand, and you will have a perfect filter. Allow the foul water to filter slowly through the above filter, and you will produce a remarkably pure drinking water. Before placing the iron filings in the filter, they must be well washed in a hot solution of soda or potash, to remove oil and other impurities, then rinse them with clean water; the filings should be mixed with an equal measure of fine charcoal. If the water is very foul, it must be allowed to filter very slowly. The deeper the bed of iron filings is the quicker they will act.

In Bailey-Denton's cistern filter, the principal novelty is that it runs intermittently, and thus allows the aëration of the filtering material, and the oxidation of the impurities detached from

the water. The oxidation is effected by the perfect aëration of the filtrating material, which may be of any approved kind, through which every drop of water used in the kitchen, bedrooms, and elsewhere must pass as it descends from the service cistern for use. As water is withdrawn from this filter, fresh water comes in automatically by the action of a ball-tap; and this fresh water immediately passes through the aërated material into a lower chamber, forming the supply cistern of filtered water for the whole house. The advantages claimed for the filter are that it secures pure water for the whole house. It is attached by pipe to, but is distinct from, the service cistern; it can be placed in any part of the house, and it cannot get out of order. Any approved filtering material may be used, and being aërated between each passage of water through it, oxidation is made certain.

A slate or iron cistern and filter combined may be made by dividing the cistern with a vertical partition perforated at the bottom, and placing in the half of the cistern which receives the water, a bed of filtering material, say 6 in. of gravel at the bottom, 6 in. animal charcoal in granular form in the middle, and 6 in. clean sharp sand at the top, covering all by a perforated distributing slab.

The following remarks relate to apparatus and materials for filtering rain water that is stored in cisterns, especially for drinking and cooking purposes.

Among the things to consider in determining whether cistern water is safe to drink, are the cleanly or dirty condition of the roof, and the materials it is made of; whether leaves from overhanging trees fall upon the roof and lodge in the gutters; whether birds foul the roof; whether it is made of wood, slate, or tin, or of materials inimical to health—as lead, copper, or covered with deleterious paints.

The water taken from a cistern fed from a roof encumbered with leaves from an oak tree has been found so strongly impregnated with tannic acid as to turn black when boiled in an iron pot.

In order to obtain the best results from filtering cisterns, the roof and gutters should be kept free from leaves and dirt, and it is also advisable to arrange the leader with a switch valve, with the handle convenient for operating within the building, so that the first wash may carry away the dust, dirt, or other foul matter, and thus save only the best water.

Caution should be exercised in locating cisterns that are intended to furnish drinking and potable water, that they be away from the influence of cesspools and privies, as clean water readily absorbs the odours, gases, and germs of foul air.

The materials selected for filter beds should be in accordance with the resources of the locality in which the filter is to be used, for the purpose of renewal.

We recommend such materials only as have proved reliable, leaving out all textile or organic substances, as we deem such unfit for this class of filtration.

Pulverised charcoal mixed with sand, or between layers of sand and gravel, so long used for filtering purposes, has a cleansing or antiseptic power, probably derived from the contact of a large carbon surface. Pulverised coke has been used, and is considered a fair filtrant, but less effective than charcoal. Bone charcoal has also been recommended as being highly antiseptic, besides having a strong absorbent power, due to the variety of its chemical components.

Spongy iron, or pulverised hematite mixed with sawdust and roasted; pulverised magnetic iron ore and clean scale from a blacksmith's anvil, pulverised and mixed with clean, sharp sand, have been much used and experimented with in Europe with great success, in not only making fetid water sweet, but it is also claimed that the iron mixtures destroy bacteria and their germs.

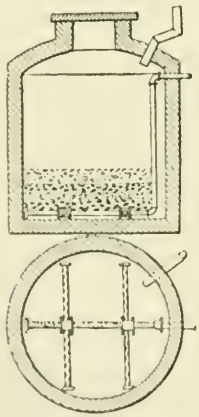
A combination of two extremes, a

large carbon surface in charcoal and the pungent oxidising qualities of the spongy iron, or its equivalents, will no doubt become the acme of a filter.

From experiments made with the filters of public waterworks in Europe, for the quantity of water that a filter will yield per square foot of surface, it has been ascertained that, with a filter composed of 10 parts fine sharp sand, 1 part coarse sand, 15 parts spongy iron mixed with one-third its bulk of fine gravel, laid upon a strainer of perforated galvanised iron—a bed of brick laid close—or a stratum of gravel covering a perforated iron pipe, a yield of 1 gal. of clear, pure water for each foot in depth per hour for each square foot of surface: 4 ft. being the greatest depth with a yield of 4 gal. per foot per hour—illustrating the probable fact that the velocity of the water corresponds with the depth of the filtering material for equal purity.

Figure 161 illustrates a method of preparing an ordinary house cistern for

FIG. 161.



filtering. The pipe and fittings should be of galvanised iron; black or plain iron is better as long as it lasts, as it rusts fast; in either case it is better to waste the water first drawn, for the water absorbs both the zinc and the iron when standing over night. The zinc is not healthy, and the taste of the iron is unpleasant.

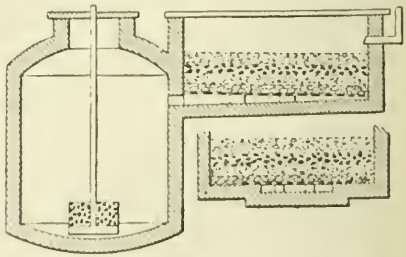
The perforations should equal 3 or 4 times the area of the suction pipe, which in ordinary cisterns may be $1\frac{1}{4}$ in. pipe, while the branches may be $\frac{3}{4}$ in. pipe. The holes, if $\frac{1}{8}$ in., should number at least 200, distributed along the lower half of the pipes. Smaller holes are preferable; of $\frac{1}{16}$-in. holes, 800 will be required.

For the filtering material we recommend a layer of fine gravel or pebbles for the bottom, 3 or 4 in. in depth, or heaped up over the perforated pipes; upon this a layer of sharp, clean sand, 9 in. in depth; upon this a stratum of pulverised charcoal, not dust, but granulated to size of peas or beans, or any of the material above mentioned, 4 in. deep; and upon this a stratum of fine, clean sand 6 to 12 in. in depth.

Such a filter should be cleansed at least twice in a year by pumping out all the water, taking out the mud or settlings, and one-half the depth of the top layer, and replacing with fresh sand.

The double filter cistern, Fig. 162, has much to recommend it, having a

FIG. 162.



large receiving basin which in itself is a filter placed in a position for easy cleaning. The recess at the bottom may be covered with a perforated plate of galvanised sheet iron, upon which may be laid a filter bed of gravel, sand, charcoal, spongy iron, and sand in the

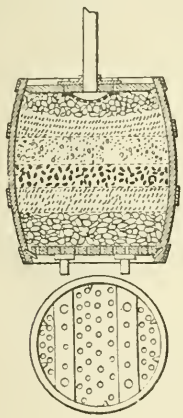
proportions as stated above. This enables the frequent cleaning by removing the top layer of the filter bed without disturbing the water supply. The cover should fit tight enough to keep out insects and vermin.

A double-bottomed basin perforated and filled with clear, sharp sand and charcoal should be attached to the bottom of the pump pipe, as shown.

This enables the small filter to be drawn up and cleaned, without the necessity of emptying the cistern or interrupting the water supply.

The half barrel or keg filter, as illustrated in Fig. 163, is a convenient form of cistern filter where filtered water is required from cisterns already filled.

Fig. 163.



This is also a convenient form for readily cleaning or changing the filter without the necessity of discharging the water from the cistern.

This filter can be made from an oak keg or half barrel, such as is used for liquors or beer. Take out one of the heads and cut away the edge, so that it will just drive into the end of the keg, fasten 2 battens of oak across the head with oak pins left long enough to serve for legs for the filter to rest upon.

Bore this head full of holes ¼ in. diameter. In the other head bore a hole 1¼ in. diameter, and bolt an iron flange into which the pump pipe is to be screwed. Let the bolts also fasten upon the inside a raised disc of galvanised sheet iron, perforated with a sharp point or chisel. Proceed to charge the filter by turning the top or flanged head down, and placing next the perforated plate a layer of fine gravel 3 in. thick, then a layer of sharp, clean sand 3 in. thick, then a layer of pulverised charcoal free from dust, 3 in. thick, then a layer of sharp clean sand mixed with spongy iron, pulverised magnetic iron ore, or blacksmiths' scales, followed by a layer of coarse sand, gravel, and broken stone, or hard burnt bricks broken into chips to fill up. Place the perforated bottom in as far as the head was originally; bore and drive a half dozen oak pegs around the chine to fasten the head. Then turn over the filter, screw the pump pipe into the flange, and let it down into the cistern.

Such a filter requires to be taken out and the filtering renewed in 6 to 12 months, depending upon the cleanliness of the water catch. With the precautions mentioned above in regard to the care of the roof, such a filter should do good work for one year.

A country resident thus describes the manner in which he utilised rain-water, falling upon an ordinary tin roof, covered with some sort of metallic paint, said to contain no lead, and flowing into a large cemented brick cistern, whence it was pumped into the kitchen. The cistern differed from the usual construction in this manner: across the bottom, about 3 ft. nearer one side than the other, was excavated a trough or ditch about 2 ft. wide and 2 ft. deep; along the centre of this depression was built a brick wall from the bottom up to the top of the cistern, and having a few openings left through it at the very bottom. The whole cistern, bottom, sides, and canal included, was then cemented as usual, excepting the division wall. Upon each side of the wall, at its base, 6–12 in. of charcoal were laid, and covered with well-washed

stones to a further height of 6 in., merely to keep the charcoal from floating. The rain-water running from the roof into the larger division of the cistern, passes through the stone covering, the charcoal, the wall, the charcoal upon the other side, lastly, the stones, and is now ready for the pump placed in this smaller part. It is much better that the water at first pass into the larger division, as the filtration will be slower, and the cistern not so likely to overflow under a very heavy rainfall. He used this cistern for many years, and was troubled only once, when some toads made their entrance at the top, which was just at the surface of the ground, soon making their presence known by a decided change in the flavour of the water.

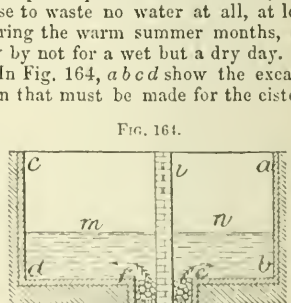
If the house chances to be in a dusty situation, several plans will suggest themselves whereby a few gallons at the first of each rain may be prevented from entering the cistern. Should the house be small, and therefore the supply of water from its roof be limited, do not lessen the size of the cistern, but rather increase it, for with one of less capacity some of the supply must occasionally be allowed to go to waste during a wet time, and you will suffer in a drought, whereas a cistern that never overflows is the more to be relied upon in a long season without rain.

Rainfall varies exceedingly in different places, and even in the same situation it is impossible to foretell the amount to be expected during any short period of time, but the most careful observations show that about 4 ft. in depth descends at New York and vicinity every year, or nearly 1 in. a week. If this amount were to be furnished uniformly every week, the size of a cistern need only be sufficient to contain one week's supply, but we often have periods of 4 weeks without receiving the average of one, and we must build accordingly.

The weekly average of 1 in. equals 1 cub. ft. upon every 12 ft. of surface, or 3630 cub. ft. upon an acre, weighing about 113 tons. Upon a roof 40 ft. by 40 ft., 1600 sq. ft., it would be 133 cub. ft., 1037 gal., or about 26 barrels of 40 gal. each. A cistern 8 ft. across and 10 ft. deep would contain 502 cub. ft.; and one of 10 ft. across and 10 ft. deep, 785 cub. ft., or 6120 gal.—about the average fall upon a roof of the above size for 6 weeks; while the smaller cistern would hold 3900 gal., or a little less than 4 weeks' rainfall. The weekly supply of 1037 gal. is equal to 148 gal. per day, or nearly 15 gal. to each individual of a family of 10. This is certainly enough, and more than enough, if used as it should be; but where water is plentiful it is wasted, and in our capricious climate, whether we depend upon wells or cisterns, it is wise to waste no water at all, at least during the warm summer months, and lay by not for a wet but a dry day.

In Fig. 164, *a b c d* show the excavation that must be made for the cistern,

FIG. 164.



and supposing the diagram to exhibit, as it does, a section of the cistern, the receptacle for the water will be, when finished, taking the relative proportions of the different parts into consideration, just about 9 ft. wide and 4½ ft. deep. Of course, the excavation must be made greater in breadth and depth than the dimensions given, to allow for the surrounding walls and the bottom. The walls may be of brick, cemented within, and backed with concrete or puddled clay without, or of monolithic concrete; but the bottom, in any case, should be made of concrete. The trench *e f g h* running across the bottom of the cistern is 2 ft. broad and 2 ft. deep. In the middle of this opening is built up a 9-

in. brick wall, or a party-wall of concrete, *i k*. Along the bottom of the wall openings *l* are left at intervals. The party-wall divides the entire space into the larger outer cistern *m*, and the smaller inner cistern *n*. Supposing the breadth from *e* to *f* to be 2 ft., and the wall 9 in., spaces of 7½ in. will be left on each side of the wall. These are filled to ¾ the height, or for 18 in., with lumps of charcoal, smooth pebbles, 1–3 in. in diameter being laid along the top of the charcoal till the trench is filled up. The cistern is so constructed that the water from the roof enters *m*; it passes downwards through the stones and charcoal, as shown by the arrow at *f*, passes through the opening, and forces its way upwards in the direction of the arrow at *e* into the cistern *n*, in which it rises to the level of the water in *m*, to be drawn thence for use by a small pump.

Laboratory Filters. — Text-books generally remark at the outset that it is very necessary to use a funnel, the sides of which form an angle of 60°, this being the angle formed by the folded paper. Symes takes exception to this very exacting requirement. We do not get our straining bags or percolators made of such a shape, and that because our experience teaches us how much more suitable is a form in which the angle is decidedly more acute, the same volume of liquid in this latter form producing a longer column, and consequently a greater downward pressure. Then, as to the paper fitting the funnel, we know quite well that all else being equal, the less perfectly it fits, the more rapidly filtration proceeds, so that, for any useful purpose, it is quite unnecessary to insist on this very orthodox shape. One has, say, a pint of fluid to filter, and for this purpose a funnel of about 8 oz. or 10 oz. capacity is taken. Symes would use one of the long French pattern, fold the filter in plaits, and before opening it out, place it fairly well down in its position in the funnel, or, if there were reasons for not plaiting the filter, then it should be folded first in half, and then the two outer portions, representing rather more than ⅛ each of the entire paper, should be turned back so as to overlap each other slightly at the top, and not to form a very acute point. In either case, the paper, whilst being fairly well supported, would have comparatively little surface adhesion, and but small resistance would be offered to the passage of the fluid in any part. Funnels of this shape, in much larger sizes, can be used with advantage, but it is then desirable to have them ribbed. The ribs of funnels (especially of large ones) to be of any real value, should be much deeper than they usually are, and should not run vertically, but spirally. A piece of muslin placed between the paper and funnel not only strengthens and supports the paper, but assists filtration by preventing adhesion; a cone formed of coarse hair cloth is still better. For larger sizes, say of 4 to 8 pints, it is advantageous to dispense with the funnel altogether, and to use an inverted cone formed of linen or stout calico, the edges being fastened to a wooden hoop, which, resting on a deep earthenware pan, forms an efficient support for the paper, the liquid passing through with equal facility over the entire surface, a suitable cover placed over it excluding the air, and the process goes on under comparatively satisfactory conditions. A self-feeding arrangement can be fitted to this if it be so desired, in a very simple manner.

When, by exhausting the receiver, atmospheric pressure is brought to bear on the liquid in a funnel, then the latter should be of the *orthodox* shape, as with it air is less likely to pass; but this requirement militates against the advantage that such a method would otherwise possess. The point of the filter should be supported by a cone of platinum, or zinc, or by a packing of tow or prepared wool.

English paper-makers do not appear to have devoted much attention to the production of filters in any variety, and for this reason we derive our supplies chiefly from the Continent. It is a well-known fact that holding almost

any of the common filters up before a strong light they are seen to be perforated more or less with minute pinholes, so that, when in use, it is only after these have become filled up that the whole of the solid matter is separated, and the liquid passes through bright. Each time a fresh portion of liquid is added the disturbance caused thereby is liable to remove some of the particles which are acting as a filling, and if this occurs, filtration again becomes imperfect. These filters, although very cheap, do not pay to use if time and convenience are taken into consideration. There is, however, considerable difference in the efficiency of the various kinds of filtering papers, even when free from this defect. The presence of animal matter, as in the grey filter, increases the strength, but diminishes its working capabilities, and the existence of mineral matters therein does the latter, but not the former. The papers specially prepared by Schleicher and Schüll are practically free from all extraneous matters, the pulp having been treated with hydrochloric and hydrofluoric acids, &c. They are an example of what can be accomplished in this respect, but at the same time they are too expensive for general pharmaceutical purposes, and, indeed, are only made in comparatively small sizes, suitable for analytical work. For operations requiring filters of 7 in. diameter (before folding), the Rhenish papers, No. 595, are, in Symes' opinion, the most suitable; for larger sizes, the French stout plaited or plain papers, taken in all their qualities, give the best results. The French also make a paper specially suitable for syrups, thick to support the weight, and yet sufficiently pervious to allow of fairly rapid filtration. Symes finds, however, in very large sizes, a double sheet of Rhenish paper in an inverted case of linen, as already described, answers even better.

Filter-paper which has been immersed in nitric acid (sp. gr. 1·42) and washed with water is remarkably toughened, the product being pervious to liquids, and quite different from parchment-paper made with sulphuric acid. Such paper can be washed and rubbed without damage, like a piece of linen. The paper contracts in size under the treatment, and the ash is diminished; it undergoes a slight decrease in weight, and contains no nitrogen. Whereas a loop formed from a strip 25 *mm.* wide of ordinary Swedish paper gave way when weighted with 100–150 *grm.*, a similar loop of toughened paper bore a weight of about 1·5 *kilo.* The toughened paper can be used with the vacuum pump in ordinary funnels without extra support, and fits sufficiently closely to prevent undue access of air, which is not the case with parchment-paper. An admirable way of preparing filters for the pump is to dip only the apex of the folded paper into nitric acid and then wash with water; the weak part is thus effectually toughened.

Some fabrics, such as swansdown, close-textured twill calico, &c., filter as brightly as paper does, and may be used for that purpose as distinct from ordinary straining, provided the solid particles separate from the liquid in which they are suspended with ease, but when this is not the case, they are of much less value; indeed, with paper as a medium, slimy deposits present considerable difficulty. Pepsin wine, prepared from the fresh, undried pepsin, might be regarded as typical of this class of liquids, the tendency being to choke up the pores of the filter almost immediately the operation commences. In such cases, some kind of coarse straining material placed within the paper cone helps materially to obviate the difficulty. Hair cloth, and thin coarse flannel answer well for this purpose; they operate by collecting on their rough projecting surfaces the larger proportion of the undissolved slimy matter, without becoming sufficiently choked up to materially impede the progress of the operation.

Succus taraxaci, as expressed from the root and mixed with spirit according to the B. P. instructions, is typical of a class containing a large quantity of

starchy matter and where subsidence in a closed vessel previous to filtration is of great service. The liquor from poppy capsules, in the process of preparing syrupus papaveris alb., furnishes us with an example of a liquid containing a large quantity of albuminous matter and mucilage which, when coagulated by spirit, has to be filtered off, and here again subsidence in a closed vessel helps the separation materially. The greater portion of the liquor can, after a time, be poured almost bright into the filter, and the remaining soft mass can, with care, be slowly pressed almost dry, the chief difficulty in the latter operation being to press sufficiently slowly to separate the liquid from the solid, and yet not to expose it to the air long enough to lose much spirit by evaporation, as in that case some of the solid portion would be again taken up in imperfect solution.

The *Druggists' Circular* recommends chamois skin, free from thin places, cut of the desired size, washed in a weak solution of any alkali, to remove the grease, and rinsed thoroughly in cold water before using. Tinctures, elixirs, sirups, and even mucilages are filtered rapidly. A pint of the thickest sirup will run through in 4–5 minutes. By washing thoroughly after each time of using, it will last a long time.

For removing suspended particles from strong acids, spun glass, known as "glass wool," answers best, but this might be regarded as straining rather than filtration. With ordinary liquids, when there is but little insoluble matter, absorbent cotton not only strains, but by fairly tight packing, filters brightly. In cases where it is desired to save the deposit, and possibly to dry or incinerate it, asbestos paper can be recommended; the liquid passes through it slowly, but it is very strong, and it is indestructible by heat. Paper lint, as introduced from America some few years ago, answered well as a filtering medium, being both strong and absorbent.

So far we have considered filtration as conducted only in funnels or funnel-shaped arrangements, as the various forms in which atmospheric pressure is commonly employed are described in works which treat of such matters. They are chiefly those in which a long column of liquid is carried above the point of filtration, as in Proctor's arrangement, where exhaustion is obtained by means of a syringe underneath, or suction by means of a bent tube, as described by Schacht at the meeting of the Conference at Birmingham, in 1865.

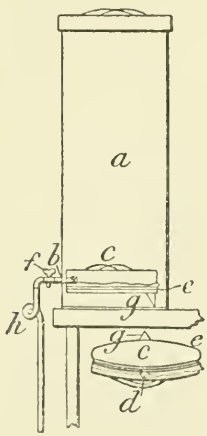
Symes considers that upward filtration is the direction from which we may expect the best results.

Some years ago, William R. Warner, of Philadelphia, invented an oil filter on this principle, consisting of 2 vessels in superposition, measuring altogether about 40 in. in height by 10 in. in diameter, and which is said to be capable of filtering a barrel of oil per day. This, of course, would depend on the nature of the oil and the temperature at which it is used.

Recently Symes devised a form of upward filter in one vessel only, and added to it a suction tube. It occupies comparatively little space, is simple in construction, efficient in action, and can be made by any tinman at little cost. It is shown in Fig. 165, and consists of a plain tin cylindrical vessel *a*, with a tap-hole *b* 1½ in. from the bottom; it is 22 in. high, and 8 in. in diameter. A tin tray *c*, 7 in. in diameter, with a vertical rim 1–1¼ in. deep, has a hole *d* in the rim, this and the hole near the bottom of the cylinder being fitted with a short female screw of the same pitch of thread. Over the tray, the filtering material *c* (flannel, calico, paper supported by muslin, or any other material that may be suited to the liquid to be operated on) is tied securely; it is then inverted and placed in the cylinder so that the holes *b d* are exactly opposite one another. A tap *f*, with a bend at a right angle, is screwed in so that it holds the two together, and assists a short leg *g* in supporting the tray in position. To the end of the tap is attached a rubber tube turned on it-

self *h*, or a long glass tube of similar construction (in fact, take a large safety funnel deprived of the thistle head), which can be attached by a short piece of rubber tube. It will be obvious that

FIG. 165.



any communication between the tap and the contents of the vessel must be made through the filtering medium which covers the inverted tray, and that any deposition which takes place must be on the bottom of the vessel itself, or on the opposite side of the tray, but not on the filtering surface, and herein lie the special advantages of the filter. The use of a long delivery tube is not new; it formed part of an oil filter patented by Britten, of Liverpool, some years before Schacht's application of it to his filter. Neither is upward filtration new, as already stated; but the combination of the two, and in this particular form, will probably commend itself to any one who will give it a trial. The dimensions given furnish a filter of about 3 gal. capacity, at a cost of some 10–12*s*. (*Pharm. Jour.*)

A dealer in wares used by chemists informed Casamajor that he had many inquiries concerning asbestos for filtering liquids in chemical analysis. Some chemists complain that they cannot get clear solutions through asbestos, while others, who obtain clear solutions, find that their liquids filter altogether too slowly.

The method of making asbestos filters, by pouring a thin paste of this material over a perforated platinum disc, was first proposed by Casamajor in 1875, but he neglected to give directions concerning the preparation of asbestos, to make it fit for filtering liquids in chemical analysis. It now appears, however, that such directions would be found useful.

The kind of asbestos to use is a matter of some importance. He tried 3 kinds, which are sold by dealers in New York as "Canadian," "Italian," and "Australian." This last is less flexible than the other two, and consequently the fibres do not felt together and pack as closely on the perforated plate. Hence, liquids filter more rapidly, and the Australian is, on this account, preferable to the other two kinds. He was informed that the Canadian asbestos is the most soluble in acids, but has not verified the assertion.

Whatever may be the kind of asbestos used, the following is a process for obtaining, with little trouble, a quantity of the pulp in a fit state for filtration:

A coarse brass sieve is placed over a sheet of paper, and a handful of asbestos is rubbed pretty roughly over the sieve-cloth. This breaks it up in such a way that the smaller fragments pass through the meshes, and are deposited on the paper underneath. After a while, the portion which remains on the sieve-cloth is collected in one bundle, and rubbed again in the same manner, and the operation is repeated until a sufficient quantity has gone through. In a few minutes enough of the material is obtained to last for months.

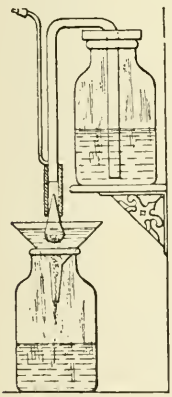
As to the coarseness of mesh to use, Casamajor has used No. 10 sieve (10 openings to the inch) with satisfactory results. The sieve is best placed bottom up, so as to leave plenty of room under the cloth.

The next operation is to free the sifted material from dust and from the finest particles. This is easily accomplished by placing the asbestos, as obtained above, over another sieve of finer mesh (about No. 25 or No. 30), and stirring it while water is poured over the sieve. The first water which passes through is quite milky, but it gradually becomes clearer as the washing is continued. The washed asbestos is then put in a beaker glass, and boiled for about ½ hour with strong hydrochloric acid (about 1 part of fuming HCl to 4 of water).

The pulp, after this treatment, is poured over a perforated platinum plate placed in a funnel, and washed with distilled water until no acidity is shown by litmus paper. The pulp is then taken out of the funnel and strongly heated in a platinum dish. After letting it cool sufficiently, it may be placed in a wide-mouth bottle for future use. (*Jour. Amer. Chem. Soc.*)

Fig. 166 shows an improved method of supplying liquid to a funnel filter,

FIG. 166.



invented by E. E. Robinson, and described in the *Chemical News*. When large quantities of liquids, such as reagents, have to be filtered in the laboratory, it is often convenient to have some means by which the funnel filter may be kept filled. The handling of large bottles for the purpose of emptying the liquid into the filter is disagreeable and tiresome. By the arrangement shown, such labour is avoided and the liquid is at the same time silently but surely transferred to the filter.

To the longer limb of the siphon is attached a short rubber tube. Operating vertically within the lower end of the tube is the narrow conical stem of a glass bulb float, in the bottom of which are 2 or 3 small lead shot or weights for the purpose of retaining the stem of the float in a vertical position.

As the liquid in the funnel filters out, the glass bulb descends, which in turn opens the bottom of the surrounding rubber pipe and permits the liquid in the siphon to flow out, falling over the bulb. If the liquid from the siphon flows faster than that through the filter, the bulb rises, and by its conical form wedges against the inner lower periphery of the rubber pipe, plugging the same, and stopping the flow therefrom. By this means the funnel is kept constantly supplied until all the liquid in the upper bottle has been siphoned out. An important advantage of this arrangement is that when once started it can be left without attention until the filtration is completed.

FIG. 167.

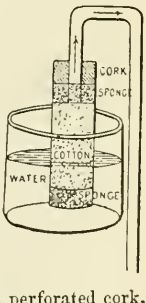


Fig. 167 shows a very simple apparatus for filtering water. Take a glass tube about 1 yd. long and of ¼-in. bore, and bend it twice at a right angle, as shown, so that the longer leg is about 6 times as long as the shorter. To the shorter leg is fastened, by means of a perforated cork, a wider glass tube, about 4¾ in. long and ⅞ in. wide (inside); this tube is filled with absorbent cotton (freed from fat), a small piece of perfectly clean sponge being laid next to the cork, and

a similar piece being used to close the other opening of the tube. In place of the narrow glass tube, a rubber tube may also be used. The apparatus is started like any other kind of siphon, and will be found to work well in all cases where the liquid is not too much loaded with suspended matters.

Dr. Ebermayer reports that he has found muslin, which is folded in shape of a filter, and placed below the latter, to be an excellent promoter of rapid filtration. He had occasion to make use of such additional muslin filters, for the purpose of removing the paper-filters from the funnel, without tearing; and he thereby had occasion to notice this useful property of the additional muslin filter. (*New Remedies.*)

It is known that certain precipitates, such as sulphur, in emulsion pass through filter paper. Boisbaudran often employs a method which in many cases obviates this inconvenience, and which, to his knowledge, has not yet been made public. Filter paper is boiled with *aqua regia* until the mass is fluidified; it is then poured into a large quantity of water, and the white precipitate formed is washed by decantation. To render the texture of a filter very compact, it is filled with this material, previously stirred up in water, so as to form a very thin paste, and allowed to drain. The paper is thus covered with a layer, which obstructs its pores. Or a little of the same pasty matter may be mixed with the liquid to be filtered.

Eiselt recommends the use of sponge for filtering distilled water. The filtration goes on with great rapidity, and the product is clear as crystal. When filtered through paper, distilled water soon exhibits a "felty" sediment, which is never formed when filtered through sponge, so that the bottles scarcely need cleaning after several months' use. The apparatus that he employs consists of a bottle with an opening near the bottom from which descends a bent glass tube. This tube is about 6 in. long and 1–1½ in. in diameter; at each end is a perforated rubber stopper bearing a narrower glass tube. The wide tube contains one or two long strips of fine sponge that has been cleaned with dilute hydrochloric acid and then dried. The bottle to which this filter is attached must not be larger than the one placed beneath to catch the filtrate. The sponge, of course, must be cleaned every few months. (*Neuste Erfahrungen.*)

Guncotton is scarcely acted upon by the most energetic chemical agents at ordinary temperatures, and may therefore be used as a filtering medium for solutions containing strong acids or alkalies.

G. F. Burton, of Springfield, Ohio, is the inventor and manufacturer of an appliance shown in Fig. 168, to be used

FIG. 168.

in connection with an ordinary funnel or percolator, designed to prevent loss by evaporation and the escape of odours, and to exclude dust and flies. It will also serve as an air-tight cover to a macerating or infusion vessel. By the ordinary method of filtering and percolation one loses constantly by evaporation not only in alcohol, but often in the volatile portion of the drug: while to keep the filter or percolator supplied

requires constant attention. If filled and left at night, in the morning the filtering paper will usually be dry and gummed, or the drug in the percolator be exposed to air. These difficulties are entirely overcome by this apparatus.

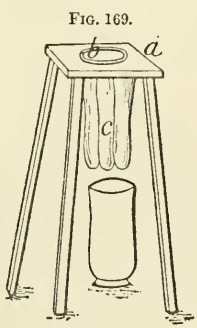
To use it. place the rubber stopper into the receiving bottle, and insert the funnel or percolator (previously packed). On this place the cover. Into a suitable discharge bottle containing the desired quantity of liquid, insert the cork with the rubber tube attached, closed by means of the pinch-cock. Secure this inverted, at a proper height, directly above the cover, and pass the rubber tube through it as far as is desirable, to permit the liquid to rise in the funnel or percolator. Press on the rubber of the cover to secure it firmly to the edge of the funnel or percolator. There should be a slight bend in the supply pipe, otherwise it might draw the cover out of place; if too much, there will not be a free flow of liquid. Loosen the pinch-cock, when the liquid will flow until it reaches the end of the tube and close it. Then no more will run until the liquid is low enough in the funnel or percolator to admit air, when more will flow as before. Should the quantity of liquid be small, or for any other reason it is not desired to use the supply vessel, insert the stopper in place of the tube.

When the liquid begins to drop from the percolator, if it is desired to set it aside for a given length of time to macerate, instead of closing the lower orifice with a cork, the flow may be stopped by closing the air-tube by means of the pinch-cock. The funnel or percolator should not exceed 8½ in. in diameter. With this size, or a little smaller, a 7-in. filtering cock and No. 33 paper can be used. If it be desired to employ vessels the full size of the cover, to secure it perfectly tight, it may be necessary to weigh it down with sand, or by filling it with water.

Filters for Liquids demanding Special Conditions.—There are some few liquids or solutions that cannot be suitably filtered in an apparatus such as may be employed for water. They are chiefly fluids of an oily, gelatinous, or syrupy character.

Gelatinous Fluids. — A simple and rapid method of filtering gelatinous mixtures will doubtless be acceptable to many photographers. The plans usually recommended are, the use of a funnel plugged with tow or cotton-wool, or a piece of cambric or other material spread over a jar, on which the solution is poured and allowed to percolate through. These plans are altogether unsuitable where large quantities of liquid have to be filtered, and even for small quantities the process is slow. The gelatine has to be kept warm till the operation is complete, and a rather open material must be employed, or the solution will only fall through drop by drop. The plan here described will be found very expeditious, there is no waste, a filtering material of the closest texture may be used, and the warm mixture is filtered before it has time to thicken by cooling. It has been used successfully for filtering gelatino-bromide emulsions and the gelatinous mixtures employed in the preparation of carbon tissue. The arrangement referred to is shown in Fig. 169: *a* is a wooden stand 18 in. high,

FIG. 169.



having a hole in the top 4 in. in diameter; *b* is a ring made of bent cane or whalebone, slightly larger than the hole in the stand. The filtering material, which must be of the closest texture, should be cut in a circular form about

22 in. in diameter; when secured to the ring with stout thread it forms a bag *c*, the ring *b* preventing it from falling through the opening in the stand.

To use the apparatus, the operator pours sufficient of the mixture into the bag to half fill it; he then seizes the bag, above the liquid, with his fingers, and presses the filtrate through into a receptacle placed below to receive it. Further portions of the mixture are poured in till the whole quantity has been filtered. With the measurements given above, quantities varying from 4 to 40 oz. may be readily operated upon. (*Photog. News.*)

Liquids affected by Air.—Fig. 170 shows a rapid-acting filter by Vollmar,

FIG. 170.

for liquids liable to change by exposure to the air. The filter is hermetically closed while working. It is lined inside with filtering paper, and the filtration takes place so that the turbid liquid enters the filter below, passes through the paper, and is discharged clear at the top, where a pipe conveys it into a receptacle. This arrangement is of special service for filtering wines or other delicate liquids which should not be long exposed to air. A siphon inserted into the cask containing the turbid liquid, which stands on an elevated place, conveys the liquid to the filter, and from there it flows into the new receptacle. If the liquid is very sensitive to air, and a layer of oil cannot affect its flavour, some pure olive oil may be poured into each cask, and the delivery tube leading from the filter be pushed down to the bottom of the receiving cask. In this way the liquid is absolutely protected from contact with air.

Lime Muds from Soda Causticisers.—These are usually drained in a filter consisting of a half boiler, cut longitudinally, loosely paved with bricks, which are covered with layers of coke to a depth of 9 in. or so; the bottom layer is composed of good-sized lumps, the top of small pieces, surmounted by a covering of coarse sand or cinders. Over the filter-bed are laid perforated iron plates or grids, upon which the mud is placed.

Syrups.—The filtration of syrups and saccharine fluids is largely performed in what are familiarly known as "bag" or "Taylor" filters. The construction and arrangement of these are shown in Figs. 171, 172. The filter consists of a wrought-iron case *a*, with openings at *b*, and an internal flange at top to carry a cast-iron box *c*, having holes in the bottom, for the reception of gun-metal bells *d*, to which are attached cotton-twill filter-bags *e*. Fig. 172 shows an enlarged section of the gun-metal bell *d*. The bags *e* fastened to these bells are 3–6 ft. in circumference and 6–10 ft. long, woven without a seam. They are crumpled up inside "sheaths" of strong open webbing, about 18 in. in circumference, which restrict their expansion. They are arranged in series of 100 or more.

In sugar refineries use is largely made of animal charcoal, packed in huge cylinders.

Oils.—The filtration of oils may be effected in a very great variety of ways, either with or without the assistance of artificial pressure derived from (*a*) a "head" of the liquor to be filtered, (*b*) one of the many forms of filter-press in use, or (*c*) atmospheric pressure by the production of a vacuum *under* the filter-bed. For example, olive oil is mostly

subjected to no process of purification beyond what is attained by allowing it to deposit impurities and repeatedly decanting. But, for the best qualities, further purification is necessary not only to secure limpidity, but a capacity for lengthened preservation by eliminating the water, mucilage, and parenchymatous matters. Various devices are employed in different localities, one and all being filters. In France, the oil to be purified is received into perforated boxes carpeted with carded cotton (wadding); elsewhere, cotton tissue interposed between beds of granular and washed animal charcoal form the filter; a bed of dry moss, on the "Grouvelle et Jaunez" system; layers of sand, gypsum, and coke; alternate beds of sand and vegetable charcoal, according to Denis de

FIG. 171.

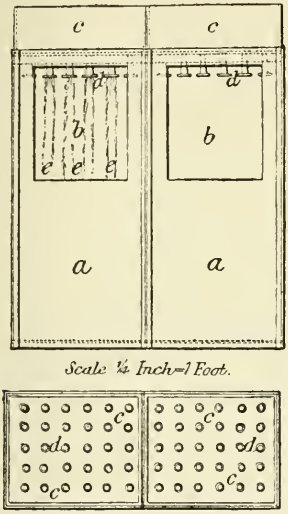


FIG. 172.

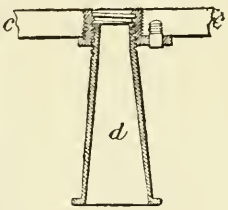
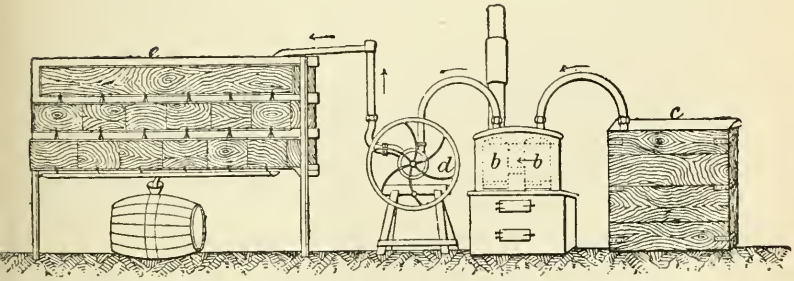


FIG. 173.



Montfort's plan; carbonised schist and peat, by Cossus' method; clay heated to 200° (? F.), as proposed by Wright; by introducing china-clay and allowing to stand at a moderate temperature, then filtering through cotton, as adopted by A. Pizarri. Perhaps the best mode is that of Pietro Isnardi, of Livornia, Tuscany, which received an award at the Vienna Exhibition. This apparatus, Fig. 173, consists of a boiler full of water, serving as a water bath for 2 turned-iron cylinders *b*, receiving the oil from the reservoir *c*, a suction- and force-pump *d*, and a filter *e*, containing perforated trays whose holes are filled with wadding. This apparatus enables the oil to be filtered without coming into contact with the air, and at an elevated temperature which can be regularly maintained. Coco-nut oil is another example of purification by simple subsidence and filtration.

PERCOLATION.—This is a kind of filtration, commonly called "by displacement," employed for extracting the essence from roots, herbs, seeds, barks, &c. It is effected in the following manner: It is first necessary that the articles to be acted upon should be ground in a drug mill to the condition of a coarse powder; then moisten the mass thoroughly with alcohol, allowing it to "macerate" for 12 hours in a vessel well covered. Next is required a hollow instrument of cylindrical form, having one end shaped like a funnel, so that it can be inserted in the neck of a glass bottle, and having inside, near the lower end, a partition pierced with numerous small holes, like the strainer of a French coffee-pot, which is a simple coffee percolator; in the absence of such a partition, soft cotton, or any insoluble substance, may be substituted, and being placed in the inside at the lower end of the instrument, will answer as well as the strainer. This instrument is called a percolator. Boullay's filter or percolator is usually employed. Macerate the ingredients to be acted upon, for the time named—introduce them into the percolator, and slightly press them upon the partition. Any portion of the liquid used in the maceration, not absorbed by the powder, should be poured upon the mass in the instrument, and allowed to percolate. Now gradually pour into the percolator sufficient of the alcohol, or other liquid to be filtered, to drive before it, or "displace," the liquid contained in the mass; the portion introduced must in like manner be "displaced" by another portion; and so on, till the required quantity of filtered liquor is obtained. This extract is called a tincture. In case the liquor which first passes through should be thick and turbid, again introduce it into the instrument, being very careful not to have the powder too coarse or loosely pressed, or it will permit the liquid to pass too quickly; and on the other hand it should not be too fine and compact, or it may offer an unnecessary resistance. Should the liquor flow too rapidly, return it to the instrument, and close it beneath for a time, and thus permit the finer parts of the powder to subside, and cause a slower percolation.

The first portion of liquid obtained by the method of displacement is always in a state of high concentration. In general, it is a simple solution of the soluble ingredients of the crude drug in the fluid employed. But sometimes the solvent, if compound, is resolved into its compound parts, and the fluid which passes through it at any given time is only *one* of these, holding in solution only the most soluble parts of the drug.

Thus, if diluted alcohol be poured over powder of myrrh, in the cylinder of the percolator, the fluid which first drops into the receiver is a solution of an oily consistence chiefly composed of resin and volatile oil dissolved in alcohol. In like manner when the powder of gall-nuts is treated in the same way by hydrated sulphuric ether, two layers of fluid are obtained, one of which is a highly concentrated solution of tannin in the water of the ether, and the other a weak solution of the same principle in pure ether. In all cases, therefore, in which it is not otherwise directed, it is absolutely necessary to agitate the several portions of the liquid obtained

by percolation together, in order to ensure a product of uniform strength or activity.

To illustrate the operation of displacement, and describe an excellent percolator for making perfume tinctures, we will suppose that benzoin is under treatment. The apparatus, made wholly of glass, having been arranged, as shown in Fig. 174, and a plug of raw cotton dropped loosely at *a*, the benzoin in coarse powder is then poured into the portion *b* until it reaches the line *c*. Alcohol (95 per cent.) is next added, until it rises to the line *d*. As soon as the first portion sinks into the benzoin, a fresh addition must be made; and thus the succeeding relays go on displacing those which preceded them without mingling with them. Each stratum becomes more and more charged with soluble matter as it descends; and when it reaches the bottom of the mass, under the pressure of the superincumbent liquor, it runs out saturated. When, by successive additions of fresh alcohol, the benzoin under treatment has become exhausted, the liquid passes through the mass, and falls into the receiver *e*, as tasteless and colourless as when first poured in. This indicates the completion of the process.

FIG. 174.

As atmospheric pressure is an important element in the operation, it will not answer to shut it off by closing the top of the displacer, without making some compensation; and, therefore, a communication between the upper and lower vessels is established by means of a latent-tube arrangement *f*. In this manner the apparatus is kept close, and the evaporation of alcohol prevented, while the pressure produced is distributed throughout the apparatus, and rendered uniform. As the runnings are clear, filtration is rarely necessary. The quantity of alcohol thus consumed need not be more than sufficient to exhaust the material; and the resulting tincture must therefore be diluted to the proper strength. For perfumes, deodorised alcohol must always be used.

The method of displacement has the advantage of expedition, economy, and yielding products possessing uniformity of strength; but it requires considerable experience to adapt it to all substances. The art rests in properly packing the ingredients in the cylinder, some substances requiring considerable pressure to be used, while others, when even lightly packed, scarcely permit the fluid to pass through them. An excellent plan, applicable to all substances, but especially those of a glutinous or mucilaginous nature, is to mix the powder with an equal bulk of well-washed sand before rubbing it up with the menstruum. The coarseness of the powder must also be attended to. Substances that readily become soft and pappy when wetted by the menstruum, should not be used so fine as those that are more woody and fibrous. The method of displacement answers well for the preparation of all tinctures that are not of a resinous nature, and for most infusions of woody and fibrous substances, as roots, woods, barks, leaves, seeds, insects, &c. It is especially adapted for the preparation of concentrated infusions and essences, as they may thus be obtained of any required strength, without loss, or requiring concentration by heat, which is so destructive to their virtues.

When ordinary tinctures are made in large quantities, displacement is never likely to supersede maceration on account of any practical advantages it may possess. If the prescribed directions be duly attended to, the process of maceration is unexceptionable. The process is more simple than the other; the mode of operating more uniform; it is, in fact, always the same; it requires less of skill and dexterity in conducting it; it requires less constant attention during its progress, which, in operating on large quantities, is a consideration; and finally, the apparatus required is less complicated. When, however, only small quan-

tities are to be made at a time, and kept in stock, the adoption of the process of displacement will often be found convenient and advantageous. It offers the means of making a tincture in 2 or 3 hours, which, by the other process, would require as many weeks.

The preceding remarks are mainly gathered from Cooley's Cyclopædia. More recently the subject has received great attention from J. U. Lloyd, of Cincinnati, Ohio, and the results of his observations are thus recorded in the Proceedings of the American Pharmaceutical Association:—

One of the most frequent operations to be performed by the pharmacist is to separate from the crude materials, offered principally by the vegetable kingdom, active principles from others inert or not desirable. This object is reached by bringing the same into the liquid state by solution, with the aid of a proper solvent (menstruum). Thus we have the process of maceration and percolation, the latter being a modification of the former, calling in the aid of gravitation. To arrive at a proper understanding of the laws which govern the solution of substances, that is, the transfer of a solid into the liquid state through the aid of solvents, we should consider first the greatest agent in percolation,—the attraction of gravitation. This unknown force impels all terrestrial bodies toward a common centre, the centre of the earth.

If we arrest the fall of a solid and pour upon it a liquid, that liquid will flow over the solid, excepting a small amount held by adhesion, and will fall from the lower surface towards the earth. If that solid be impenetrable, and insoluble in the liquid, it will remain intact; if soluble, it will gradually assume the liquid state and disappear. If the solid be porous the liquid will enter. This is due to absorption—a molecular force, which is working independent of the attraction of gravitation, and overcoming it to a limited degree, thereby exercising a great influence over the process of solution, beneficial inasmuch as it ensures a closer and more continued contact between the solvent and the solid. Thus, if a certain amount of liquid be slowly poured upon the porous body, we shall find that attraction of gravitation will fail to detach the liquid from the lower side; it does not flow over the outside, but enters, is absorbed, and held within its substance. The attraction of gravitation still exerts itself, for the actual weight of the mass is the sum of the separate weights of the 2 bodies. Without further examination we might suppose the materials at rest; such, however, is not the case. There are disturbing elements which produce constant motion; thus, an alteration of temperature will excite a change in the relative position of the molecules of the liquid, and temperature constantly changes. But besides the motions of the molecules, caused by the constantly varying changes of temperature, there is osmosis, an attraction that induces currents of liquid through cellular tissue. Gravity, however, overcomes at first all of these various contrary influences—among which we may class diffusion—and is ever tending to draw the liquid most heavily charged with soluble matters downward through the lighter, and thus there seems to be no rest, but, on the contrary, continual change.

The influences mentioned exert themselves whether the solid be large or small, whether a single particle of dust in a quantity of liquid or an innumerable number placed in a mass and covered with liquid. Let us turn our attention to solution. Throwing aside all theories as to the why and wherefore of the change of state from solid to fluid, we must accept the fact, that below the melting temperature certain solids will, to a fixed extent, assume the form of liquids if in contact with particular fluids. The conditions necessary to effect and promote this change are: surface exposed to the dissolving medium, circulation of the liquid, temperature and time of contact between the surfaces of solid and the liquid. In regard to the first of these conditions,

it is invariably found that the rapidity of solution increases with the area of the surface exposed; thus, for an example, if a cubic crystal of potassium bromide, or any other substance, 1 in. in dimension, be surrounded with water, the surface in contact with the water will be 6 sq. in. If the crystal be bisected by a plane parallel to any 2 of its sides, the amount of the material remains the same, but its surface has been increased 2 sq. in. Let each half now be divided into 4 equal parts, and there will be a total of 12 sq. in. of surface, exactly twice the amount of the original cube. Division can be theoretically, and in the above instance according to mathematical laws, continued to the extent of our imagination, and each cube divided into 8 will double the amount of the surface. But in practice we meet with obstacles of various nature which soon interpose insurmountable limits to accurate divisions, making our further efforts in that direction impracticable, and the desired increase of surface is most readily effected by pulverising the solid, thus obtaining irregular surfaces.

In considering the rest of the conditions upon which solution depends we next observe the action of currents.

Thus immerse a cubical crystal of potassium bromide 1 in. in dimension in water, and its 6 sq. in. of surface will be in contact with 6 sq. in. of water surface; immediately the 2 surfaces act together, resulting in the disintegration of the surface of the salt, which assumes the liquid form and blends with the surface of the water in the most intimate manner. This change takes place to a fixed extent, dependent upon the temperature and the saturation of the solvent. If the crystal be at the bottom of a vessel of water, it commences most rapidly to diminish in size from the top until finally it disappears. In observing closely the process we notice streams of liquid circulating about the crystal. These currents, colourless and transparent like the surrounding medium, are clearly visible from the fact that they refract the rays of light differently, an optical result caused by the portions of liquids of different densities, for the particles which form the surfaces of the salt unite with those of the water surface, resulting in a compound that has a greater specific gravity than pure water, consequently, as soon as united, this fluid flows over the crystal and down its sides in obedience to the laws of gravitation. It strikes upon the bottom of the vessel and, in response to the law that fluids of different densities seek their own level, spreads out, and in doing so displaces its bulk of water, which rises and replaces the solution about the crystal, and thus continuous currents flow over and down the sides of the crystal, and fresher menstruum is constantly taking the place of that more saturated. We might liken the foregoing to a surface of liquid resolving against a solid, each movement of which wears away the solid and decreases the wearing force of the liquid. At last, if the amount of water be sufficient, the crystal will have disappeared, and at the bottom of the vessel will be found a dense solution at rest surmounted by a lighter one. Again cautiously introduce a crystal of the same salt and the afore-named phenomenon will take place, though in a less marked degree. The circulation of the medium becomes gradually less and less distinct, and finally, if the salt be in excess, disappears. There remains now a remnant of potassium bromide surrounded by a dense solution, while overlying we find almost pure water. In obedience to what is generally considered another force, which, it is thought, produces the diffusion of liquids, the solution and overlying water continually but slowly intermingle. At last they are homogeneous, preceding which, however, the remnant of crystal at the bottom of the vessel will have disappeared. The foregoing exemplifies the changes which take place, under like conditions, when the crystal is broken, excepting that the increased amount of surface contact, before considered, hastens the operation.

Thus we find that nature's laws constantly produce circulation while solution is progressing. Arguing therefrom we should be able to hasten the operation at certain stages and assist nature by frequently stirring the entire liquid, thus mixing the solutions. Recognising the theoretical value of circulation and extent of surface, when we wish to dissolve substances we should powder them, and stir the liquids at short intervals.

Temperature is most important. With a few exceptions substances dissolve to a greater extent in warm than in cold liquids, and even though the material be scarcely more soluble in the hot menstruum it dissolves more rapidly. This results from the fact that liquids while rapidly changing temperature are in a more rapid state of circulation, and heat also decreases the cohesive attraction of solids, their molecules being more easily detached from the mass, and therefore more readily unite with those of the liquid. Few operators have failed to notice the benefit of a warm room when dissolving substances. Careful manufacturers cannot allow the process of percolation to be conducted at winter temperature, even though so doing results in great saving of alcohol by lessening evaporation. Time is a consideration of importance. An appreciable amount of contact must be allowed between solvent and solid. That solutions require time for action is a principle well recognised and scarcely necessary to mention.

Having now briefly noticed the influences which govern solution, let us consider the relation between maceration and percolation, as these processes are called, bearing in mind the fact that the direct object is the solution of certain substances. Place 2 oz. of powdered buchu in a vessel and saturate thoroughly with alcohol. Then fit closely on the powder a sheet of blotting-paper, and add alcohol so that the entire amount used is 16 fl. oz.; then very carefully remove the paper so as not to disturb the powder. Now we shall have the principles of solution exemplified exactly as in the previous example, excepting instead of one crystal we have a number of very small fragments, and instead of a perfectly soluble material the substance is only partially soluble, and in addition to other forces we have capillary attraction.

Solutions of different densities quickly form throughout the interstices of the powder. These solutions are in constant motion. They are subject to the forces before mentioned, but by the predominating influence of gravitation the constant tendency of the heaviest solutions is downward, and the densest part of the solution constantly seeks the lowest point. Thus we have new surfaces presented between solvent and material, attended in the first place with a handing downward of the dissolved matter. Apparently, the liquid and the powder are at rest; actually, there is constant motion, and so long as the act of solution progresses the circulation of the menstruum continues. However, these forces cannot extend their influence above the surface of the powder. It may be suggested here that diffusion can effect the mixture. Consequently the liquid within the interstices of the powder may be strongly saturated with dissolved matters, while that just overlying is scarcely contaminated, and that near the surface of the vessel is for some time perfectly pure. Assuming now that we desire to transfer the dissolved matter equally to all portions of the liquid, we most easily accomplish the object by stirring the contents of the vessel until the menstruum above and the solution within are thoroughly incorporated. When allowed to rest, solution as before proceeds; and when we again stir the contents of the vessel, we transfer a certain proportion of dissolved matter to the overlying fluid. Each operation depletes the powder to an extent of soluble matters, and tends to produce an equilibrium between menstruum and material. The process of solution becomes gradually less active,

and at last ceases to any perceptible degree, at which point we find the liquid above the powder and the liquid within identical. However long we may allow them to remain together, and however violently they may be agitated, we cannot further deplete the powder without increase of temperature. This is maceration, and thus it is we cannot by maceration represent the powder operated upon, for when the supernatant liquid is filtered from the powder, soluble matters in proportion to the liquid within the powder must remain with it. As the liquid obtained is to the entire menstruum, so must the material in the liquid obtained be to the material dissolved by the entire menstruum.

Other inconveniences attend the practical application of this mode of extracting the soluble substances from our plants. A very serious objection is the time required—generally 2 weeks. This, perhaps, more than any other cause, interested pharmacists in a general endeavour to improve. Another desideratum was an increase of strength in the product. We will consider briefly a slight modification of this process of maceration. Let us carefully moisten 2 oz. of powdered buchu with alcohol, press firmly into a container, and cover with the same menstruum. The operation of solution will be repeated exactly as in the other example. At length the liquid within the powder, and that in the cavities between its particles will be identical. When this state arrives, we remove the material to a press, and obtain all the liquid possible by pressure.

The residual material is again finely comminuted, macerated with fresh alcohol, and again submitted to pressure; the operation being repeated as many times as is considered necessary. It at first strikes us with reference to this process, that as we constantly remove saturated liquid from the powder, and substitute perfectly pure in its place, we must soon perfectly deplete the powder. But by any ordinary means we cannot remove all the liquid, and certainly that held within the powder must contain its full proportion of dissolved matters. Therefore, assuming that it required 4 oz. of alcohol, and the liquid within the powder and that between the particles had become identical in composition, and 3 oz. of liquid were obtained (a liberal allowance), $\frac{1}{4}$ of the strength must remain in the residuum; consequently the 3 fl. oz. obtained containing $\frac{3}{4}$ of the extractive matter represent $1\frac{1}{2}$ oz. of buchu, or $\frac{1}{2}$ oz. of powder to each fl. oz., and each of the following operations dilutes this. At each successive step the powder, preceding and following maceration and expression, contains the same amount of liquid, and for every 4 oz. of alcohol applied, 4 oz. of solution are obtained, excepting loss by evaporation, which will not be considered here. Decrease in quantity of powder by having a portion of its extractive matter removed by each maceration is also disregarded. The second expressed liquid we find represents but $\frac{4}{5}$ of the extractive matters remaining in the powder, that is, $\frac{4}{5}$ of $\frac{1}{4}$, which is $\frac{1}{5}$ of the whole, or original quantity, which, added to the $\frac{3}{4}$ obtained by the first operation, make the sum of $\frac{19}{20}$ contained in 7 fl. oz. of solution, a little less than $\frac{3}{20}$ to the fl. oz. The first operation produced $\frac{5}{20}$ to the fl. oz., therefore there is a reduction of a little more than $\frac{2}{20}$ to the fl. oz. by the second maceration. Theoretically this procedure may be carried to infinity before entirely exhausting the material. Practically the exhaustion will not be as thorough as our example represents. From considerations yet to be named, the writer believes it is impossible to obtain an expressed liquid containing substances of the plant capable of being dissolved by the menstruum, in the great proportion between successive percolates indicated by this ideal example. It is invariably found that a tenth maceration will produce an appreciable amount of extractive matter, and when we come to study the constituents of plants and their relations to menstruum, it will be doubtless accepted that such must be the case. As

the matter stands, those that favour this process cannot well object to the argument and table, inasmuch as it admits of the greatest possible depletion of the powder. Others may, perhaps, with good cause, argue that theoretical proportion of soluble matter extracted will be less than the above upon the assumption that the menstruum and the inert portion of the powder are alike impregnated with soluble matter, and that the actual proportion should be between menstruum squeezed from the mixture and entire residuum. Another trouble attending this process in practice is the necessity of finely dividing or pulverising each residue before remaceration, an operation tedious and difficult to accomplish in the majority of cases, especially when large amounts of material are worked. Lloyd never succeeded to his satisfaction in a general way, without passing the residuum through a sieve after each expression, an operation not easily accomplished, especially with substances which agglutinate, although in certain instances the process is preferable to any other. Our aim we understand to be the transference of soluble matter from material to liquid, if possible representing a grain of the material with a minim of the solution. This latter result we have not yet accomplished, and cannot by either process of maceration examined. In the first case we operate directly against the laws of nature. We are continually transferring a dense solution upward. In the latter example we neglect to take advantage of nature's greatest force. We use manual labour to accomplish, in the way of separating the liquid, what gravitation will do for us to any extent, and better in every particular. Now let us modify the operation by repeating the experiment of maceration exactly as heretofore, but in a vessel with a layer of cotton at the bottom, and an exit below, care being taken to avoid stirring the powder. After the usual maceration, cautiously open the exit and allow the liquid to escape at the very bottom of the powder. As a consequence we obtain the densest liquid at first, and substitute in its stead at the surface perfectly fresh menstruum, with the advantage that the liquid extracted has always passed through the entire material. Thus we find the product is constantly decreasing in colour and flavour, and the powder is continually submitted to the action of a moving menstruum.

We use no manual labour after preparing the apparatus, and have no pressed residue to pulverise. We simply connect maceration as before examined to one of nature's most familiar laws, and in this latter experiment have an exemplification of the process which Prof. Procter recommended for the preparation of fluid extracts and tinctures. It is only a modification of the processes previously examined, differing in the manner in which the liquid is separated from the powder. It is simple in operation, easy in manipulation, and productive of satisfactory results when properly applied. It is called percolation, under which name we shall perhaps be led to examine some points of interest connected therewith, and some modifications which have been suggested as improvements over Prof. Procter's process, very properly denominated simple percolation.

Prof. Procter, in bringing before pharmacists this process to deplete a powder of soluble matters, laid no claim to originality, excepting in the application of the principle for the purpose of making tinctures and fluid extracts. He certainly was aware that the process had been in use for a similar process was recommended by Count Rumford for preparing coffee; and in 1817, C. Johnson applied the principle to the extraction of cinchona bark, saying: "The machine I use is similar to one made several years ago by Edmund Loyd and Co., 178, Strand, and does not differ essentially from any of those described in Count Rumford's eighteenth essay, and in the *Repertory of Arts*, for April and May, 1813." Of the practical application of the process, Johnson remarks, "that in the Lancaster

Public Dispensary this method is found to afford a better preparation than was formerly obtained from twice the quantity of cinchona."

Pelouze, as early as 1834, introduced percolation into the laboratory of the chemist in his method of preparing tannic acid, calling it "extraction by the process of displacement." Virtually, percolation had been employed for ages before with civilised and even partly barbarous nations, as, for example, in making saltpetre and potash.

In conducting percolation, the object being the preparation of fluid extracts, many points are essential other than the considerations mentioned heretofore. Of those the most essential to be considered are the vessel employed, the material operated upon, the menstruum used, and the manner of manipulation. Accepting the argument that percolation is for the economical extraction of soluble materials, it is of the utmost importance to study influence of contact between the menstruum and the material whose partial solution is to be effected, as we have already seen that contact, continued for a length of time, is of first necessity. Thus, if we place 1 lb. of powdered sugar, or any other soluble substance, within a cylindrical percolator of such diameter that the space occupied is 1 in. in height, and cautiously add, evenly upon the upper surface, diluted alcohol, admitting for the sake of argument that the menstruum passes evenly and regularly through the powder, the diluted alcohol in the first of the percolate will have been in contact with 1 in. of material. That which follows will have successively less material to operate upon, for the first portions of percolate are partly made up of dissolved sugar or extracted matter. Thus each preceding portion of the percolate lessens the material in the percolator, and lessens the height, thus decreasing the contact of any that may succeed, until finally only a thin layer of sugar remains, between which and the passing menstruum the contact is very slight indeed. At last the sugar disappears. For this reason, even where the material is completely soluble, our percolate should theoretically become less and less charged with dissolved matters as percolation progresses (unless it be saturated to a certain point of the percolate), and at last a comparatively large amount of menstruum should contain but a small amount of dissolved material.

Let us now imagine a like amount of powdered sugar in a percolate of less diameter. The height will be increased and the contact between the first part of percolate and powder will be greater in proportion to the increased height. Allowing, for argument, the material to occupy 8 in. in height, it will follow that the menstruum of the first portion of percolate will have passed through 8 times the height of sugar that the corresponding portion did in the former experiment, although the real amount of sugar was the same. Now, again, we have the afore-mentioned rule regarding decrease of contact. Each successive part of the percolate lessens the sugar in the percolator, and decreases the possible contact (with sugar) of all the menstruum that may follow, and under like motion of liquid the sugar decreases in each succeeding part of the percolate. It will be seen that, theoretically, each portion of the menstruum in the smaller percolator must have greater contact with the material than the corresponding meustruum of the larger, if both percolate with the same rapidity, although in both examples we operate upon similar amounts of material. Arguing therefrom we are induced to anticipate that unless the percolate from the percolator of greater diameter is saturated with sugar, that which corresponds from the smaller will contain more dissolved matter, for after 1 in.—the depth of sugar in the percolator of greatest diameter—is passed there remains in the smaller 7 in. of contact during which solution may progress. Calculating accordingly we may expect that if we spread 1 lb. of sugar so that it will occupy a depth of 1 in. in a percolator, and percolate

through it diluted alcohol enough to produce 16 fl. oz. of percolate, we will fail to obtain as much sugar in solution as though the sugar had been placed in a vessel of less diameter, thereby increasing the contact between menstruum and sugar. Applying the same rule to larger and smaller amounts of other substances, we must conclude that unless there be counterbalancing influences the amount of dissolved matter in a percolate must increase and decrease with alteration in the height of powder, other conditions being identical, and amount of percolate passing from each in a given time.

Let us not infer, however, that the conditions cannot render the foregoing to an extent inaccurate. If our material be placed loosely in the percolator as a consequence the first portion of menstruum will pass rapidly. If after the first fraction of percolate is obtained the flow be retarded by means of a stopcock, that which follows may be held in contact with the material some time longer than the first; after the second fraction is reserved the flow may be again retarded, and thus more actual contact of time induced between menstruum and material than was obtained at first, although there is continually less material within the percolator. With some substances another benefit to be derived by the latter percolates arises from the fact that if the material be not finely divided or pressed firmly into the percolator the first portion of percolate flows over the particles and through the interstices between, thus preventing the menstruum flow coming into close contact with soluble materials. Gradually, however, the material may absorb menstruum, and expanding fill up those interstices, thus forcing the passing percolate to seek more and more the capillary passages through the material, and thus give a larger amount of dissolved material to a portion of percolate succeeding a certain amount of the first. To an extent this result may occur from a somewhat similar cause, even with materials perfectly soluble in the menstruum, as, for an example, sugar or salt. With small amounts of loosely packed granulated sugar the first part of a percolate of diluted alcohol or water quickly finds the exit of the percolator, but the surfaces of the particles are in the meantime softened and the mass contracts. The interstices become filled with thick syrup or solution, and thus the percolates that follow are for a time retarded. It will be noticed that the foregoing discrepancies result simply from imperfect contact, or, as we may say, imperfect maceration.

We will now consider another phase of the subject. Will a certain amount of material, occupying a height of 10 in., yield to corresponding portions of percolate less dissolved matter than a smaller amount in a percolator of such size as to make the height 20 in.? If we accept the foregoing arguments we must conclude this will be the case to a certain point of the operation, unless the percolate from each percolator is saturated, as each drop of menstruum passing through the one will come into contact with a larger portion of material than that from the other, until a certain amount of soluble matter is carried from the smallest amount of material, when it will naturally follow that the percolate from the largest amount of material will contain more dissolved matter. In other words, the first portion of percolate from the material occupying the greatest height will excel the other, while afterwards the case will be reversed. Perpendicular height should govern to this extent the result from this standpoint regardless of quantity. For the greatest contact between powder and menstruums, moving with like rapidity, must be where there is greater height of powder regardless of breadth.

In considering now that phase of contact between menstruum and solid, called maceration, in connection with percolation, one cannot find any influence at work arising from a force other than those simply due to a prolongation of contact before considered. The passing menstruum is retarded, thus permitting a longer time for the action of

the solvent. In treating of this entire subject let us bear constantly in mind that our aim is to dissolve solid substances, and that the various modifications of the processes are simply influences affecting solution.

If we close the exit of our percolator at any time during the progress of percolation, the menstruum within the percolator will necessarily cease to move bodily downward. The liquid will thus remain in direct contact with the material, and as a consequence the act of solution will progress in a manner similar to that exemplified by our example of the dissolving crystal of potassium bromide. Hence, it is evident that no other advantage than those resulting from longer continued contact can arise. To guard against any disturbing influence affecting succeeding percolation, caused by an unequal contraction of the only partially saturated powder, it is to be observed that all particles of material are equally and permanently surrounded by menstruum. We must bear in mind that the action of the menstruum upon the powdered material in the percolator, which consists of a number of small fragments, and that upon the single crystal of potassium bromide, in the example cited heretofore, differ only in degree; its solvent power affects alike all the molecules exposed to its influence, and the relative difference is dependent solely upon the difference of the areas of surface exposed to contact. In fact, the term molecule implies no definite idea of size, and is an expression applying to something beyond our senses; we cannot compare the molecules of a liquid to particles of matter of any conceivable size. We are forced to assume that a menstruum is made up of an inconceivably large number of infinitely small particles, which we consider capable of permeating the powder within the percolator, finding its way through the capillary channels which surround the particles of the solid, circulating around them in obedience to laws already considered, and according to influences yet to be mentioned.

During the process of maceration in the percolator the capillary tubes, as well as the larger interstices, are supposed to be filled with liquid; if this liquid be capable of dissolving wholly or partially the solid, solution must take place. Each successive movement of contact is found to decrease the quantity of matter held in solution until the liquid is saturated or the solid dissolved. Thus we find the effect of contact in percolation to be identical with that in simple maceration.

In percolation, from the instant the stratum of menstruum commences to penetrate the material until it escapes, we have maceration connected with alteration of the position of the mass of the liquid. There are continually new surfaces of contact formed as the liquid passes downward towards the exit of the percolator, and in maceration this phenomenon is also presented. There is no rest within the vessel while solution progresses. Mediums of greater specific gravity than the original menstruum are constantly forming, which, obedient to gravity, seek the lowest portion of the vessel, in turn to be displaced by heavier liquids. In this way, during maceration numbers of percolating currents are flowing throughout the capillaries, and between the interstices of the material, as in percolation, while fresh portions of liquid are continually coming into contact with new surfaces, and saturations are giving way with perfect regularity to those not saturated.

Thus circulation of currents progresses and will continue until an equilibrium is established, as long as there is soluble matter and unsaturated menstruum within the percolator, and afterwards whenever the temperature is permitted to change. Therefore maceration cannot be disconnected from percolation, and as we have seen percolation must include maceration. Thus the contact of maceration and the contact of percolation are identical. Reasoning from the foregoing it may be argued that the expression, maceration in connection with percolation, is simply an expression to imply

prolonged contact of liquid with material, by which means we may overcome a defective contact of height of material within the percolator. Upon the other hand, increase of height of powder may imply prolonged maceration of the material with successive portions of menstruum.

We may be justified in arguing that the influences which modify contact are of vital interest in the study of percolation; that the solvent action of a percolating menstruum may be facilitated by judicious maceration, or by increasing the perpendicular height of the powder.

Let us now consider the vessel which contains the material known as the percolator. This is of the utmost importance, as the increase and decrease of diameter governs capacity, subservient to mathematical laws, which it is necessary to examine.

The percolator controls the height of powder under like pressure. As the diameter of the percolator decreases it is responded to by greater, and as it increases by less height, both of powder and menstruum. Thus, if a cylindrical percolator be 6 in. in diameter, and a given amount of liquid or powder occupy a height of 6 in., the same material will occupy—

13½ in. in height in a percolator 4 in. in diameter; 24 in. in height in a percolator 3 in. in diameter, and 54 in. in height in a percolator 2 in. in diameter.

This is in conformity with the mathematical law that the height of both liquid and powder increases inversely as the square of the diameter of the percolator; a rule, however, which does not apply to the increase and decrease of the resultant contact between the material and passing liquid, as a more careful examination will illustrate.

Let us represent contact by numbers. If a cylindrical or prismatic percolator be used which has been filled 1 in. with a powder, overlying which is alcohol to the depth of 1 in., it is evident that every particle of the powder which assists to form any perpendicular line or column of the powder 1 in. in height will be exposed to and come into contact with every collection of molecules in the line or column of alcohol perpendicular above, providing the alcohol passes directly through the powder from top to bottom. If we knew the number of particles of powder and the number of molecules of alcohol in their respective columns, by multiplying the numbers together the product would represent the individual contacts between particles and molecules. As before remarked, we cannot calculate the number of molecules in a given bulk, therefore we will simply call the inch of alcohol and the inch of powder one, and thus by multiplying one by one we have the product one, which we will take as unity. If the powder be 2 in. in depth and the alcohol be 1, or if the alcohol be 2 in. in depth and the powder 1, the contact will be twice as great ($2 \times 1 = 2$), and may be represented by 2. If both are 2 in. in depth, the contact will be ($2 \times 2 = 4$) twice as great as the last, or 4 times that of the first, and may be represented by 4, and so on. Let us now take a percolator and apply the foregoing law of increase of contact. For the sake of obtaining even numbers we will consider a square prism instead of a cylinder, as the principle applies alike to either, although in practice cylindrical percolators are employed.

The area of the base of a square prism 16 in. in diameter is 16×16 or 256 sq. in. If a powder properly moistened for percolation be placed in it to the depth of 1 in., above which rests 1 in. of alcohol, there will be 256 cub. in. of each layer, and yet being taken as unity when the alcohol has passed through the powder the contact will be $1 \times 1 = 1$, and thus the contact may only be represented by one. If a square prism 8 in. in diameter be considered, the area of the base will be 64 sq. in. If filled with powder to the depth of 1 in., over which rests 1 in. in depth of alcohol, each layer will contain 64 cub. in. of material, or ¼ the amount required to fill the 16 in. percolator 1 in. in depth. The 8-in. percolator would therefore have to contain 4 in. in depth of each alcohol and powder before the amount (256 cub. in.) could

be reached. Thus the contact will be $4 \times 4 = 16$.

A prism 4 in. in diameter must be filled 16 in. in depth with both alcohol and powder to contain 256 cub. in. of each material. The contact will consequently be $16 \times 16 = 256$. Thus continuing our calculations, we have the following table which expresses the contact between material and liquid, in each instance the percolator below being $\frac{1}{2}$ the diameter of that above :—

Percolator 16 in. in diameter, alcohol and powder each 1 in. deep, contact, 1.

Percolator 8 in. in diameter, alcohol and powder each 4 in. deep, contact, 16.

Percolator 4 in. in diameter, alcohol and powder each 16 in. deep, contact, 256.

Percolator 2 in. in diameter, alcohol and powder each 64 in. deep, contact, 4096.

Percolator 1 in. in diameter, alcohol and powder each 256 in. deep, contact, 65,536.

It will be seen that with the percolator 1 in. in diameter there will be 65,536 times as much contact between alcohol and powder, inch for inch, as in the 16-in. percolator. Thus we find that whereas the height of both liquid and powder increases inversely as the square of the diameter of the percolator, the contact between liquid and powder increases inversely as the fourth power of the diameter of the percolator.

As we follow a line of experiments, the solution or partial solution of one problem brings us face to face with others. Thus we are led onward, and the more thorough our study of the present, the more important we find it to carefully note the future. The utmost caution is necessary in studying nature's laws, lest from insufficient data we hastily generalise. The foregoing argument regarding the laws of contact is undoubtedly as accurate, from a theoretical view, as those of the mathematical increase and decrease of the capacity of the percolator. In practice, however, the advantage derived from increased contact of height between liquid and powder, is not by any means as great as the foregoing calculations indicate. Counteracting agencies overcome to a very great extent the theoretical advantages contact should afford.

ELECTROTYPING.—The electro-deposition of metal is much employed as a means of reproducing printing surfaces, especially being adapted for duplicating engravings and delicate work rather than ordinary type. The conduct of the process demands the provision of 3 separate rooms, for taking the moulds, working the battery, and finishing the plates respectively, efficient ventilation being a primary necessary. The battery room should not have a lower temperature than 50°–60° F. (10°–15½° C.), and demands the greatest attention in ventilation.

The fittings comprise a bench 2½–3 ft. wide, placed in a good light; a small steam or gas stove, for melting the wax; and a few imposing surfaces. Also a cupboard for storing the acids and solutions in proper stoppered jars or bottles. The floor of the battery room is best of brick; a wooden floor may be covered with sheet lead or a bed of sawdust 3–4 in. thick, with some old plaster or mortar distributed through it. Sabots and a large apron are desirable for the workman.

The formes should be imposed in screw chases, made of thick wrought iron, with a proportion of iron furniture, to withstand the heavy pressure to which they are subjected.

The pot used for melting the wax and keeping it liquid generally consists of a round sheet-iron pedestal 3 ft. high and 18 in. wide, fitted inside with a zinc or sheet-iron pan about 18 in. deep. If a steam jacket is used, it should surround the whole of the pot; if gas-heating is adopted, the burners are restricted to the bottom of the pan.

The iron moulding-boxes generally measure 10 in. by 13 in. inside, the top rising 2–3 in. for the connecting-hooks, and the sides about $\frac{1}{3}$ in. to accommodate the proper depth of wax; 2 holes are made in the head for connection by hooks to the copper rods. If the moulding frame is made with an electric

connection gripper, the pan is of brass, and fitting inside is a conducting-pan, attached by clamps to a long bar 2 in. wide, curved at the end to admit of hanging on the rods. This latter plan obviates the stopping-out process, as only the portion of the pan containing the wax is subjected to the chemical action.

The press employed may be either of the "hydraulic" or of the "toggle" pattern, according to choice.

The so-called process of "blackleading" the mould, that is coating it with graphite, is often performed by hand; but a machine for the purpose is advisable, as being certainly more economical, not only in saving labour but also graphite. When done by hand, a large percentage flies off in dust; but in the machine, the mould is so effectually closed in that no waste occurs, the surplus being received in a slanting box underneath the table.

The machine simply consists of a large box supported on legs, having in the middle a table formed of a series of rafters. To this is given a slow motion to and fro, the driving and reversing gear being placed at the back of the box. Fixed to 2 arms extending from the main shaft is a long brush, the same width as the table, having a vibrating motion of about 400 per minute. The whole is covered in by a box having a door at the end. The mould is placed on the travelling carriage or table, and a quantity of graphite is put over the surface. The machine being set in motion, the carriage carries the mould slowly backwards and forwards under the vibrating brush, and the graphite by this means is thoroughly beaten into the mould. The machine can be worked by hand.

Sometimes, when "blackleading" is done by hand, a glass-top case is used, with one end open to admit the mould and the hand of the operator. This method saves a certain quantity of graphite, but it is questionable whether, considering the loss of time caused by the necessarily confined space, and awkward position of the operator's hand, it is really better than the usually adopted plan of merely placing the mould on its back, sprinkling the graphite on the face, and brushing it well in.

Blackleading brushes are made of goats' hair, the best quality only being used, or the moulds are likely to get damaged. Economy in brushes is effected by using the blackleading machine, as the action of the brush is vertical. In some machines, canvas replaces wood for the bottom of the box (under the table) to catch the graphite; it is fixed somewhat loosely, and sloping towards the front. The vibration caused by the rapid movement of the brush slightly shakes the canvas, and the graphite is thus automatically collected at the front or lowest part.

The battery jar is a thick, cylindrical stone jar, capable of holding about 8 gal.

The depositing trough must be of a size adapted to the amount of work to be performed. It matters little what its length is, but it should be at least 3 ft. deep, and wide enough to take 2 4to moulds suspended on the same rod. The trough must be of sufficient depth to afford space under the bottom of the moulds for the sediment of the solution to settle without touching the wax, as the copper of the solution becomes denser at the bottom, and if the moulds were to be allowed to dip too low, the deposit would be uneven, being much thicker at the base, while the quality of the metal would be inferior. The trough should be made of wood, about 1½–2 in. thick, firmly bolted together on the outside. Various materials are used for the lining, thick plate-glass being sometimes adopted. In this case the joints should be made with marine glue, Canada balsam, or gutta-percha; the whole can be cemented to the wood by liquid asphaltum or pitch. It may, however, be urged against this method of lining, that the joints are apt to "perish" by the action of the acids; and should a mould by accident fall into the solution, there is a probability of the glass becoming cracked. Sheet lead,

with the joints well burned together, is the best material; solder is destroyed in time.

Several methods will suggest themselves for securing the rods which support the copper plate and the moulds. Thus a copper rod about $\frac{3}{4}$ in. thick may be placed on each side of the trough, extending from end to end, the wires or copper bands secured to these rods, and the electricity passed to the copper plates and moulds; the connections being made at the end near the battery, one rod to the zinc or positive, and the other to the silver or negative pole. Or, on the top of the side of the trough, near the wall, may be secured 2 long copper bands about $\frac{1}{2}$ in. thick and $1\frac{1}{2}$ in. wide, to which may be soldered, at proper intervals, upright sockets, in which one end of the rods rests, the other end being supported by nicks cut into the wood on the other side of the trough; one band being connected to the zinc and the other to the silver of the battery. But always take care to secure the rods in such a manner as to prevent their being accidentally shifted while the battery is in operation.

The sheet-copper bands which conduct the electricity from the battery to the trough should be about $\frac{1}{32}$ in. thick and 1 in. wide; wire has not sufficient body to carry the necessary amount of current. Their width is regulated by the extent of plate surface in the battery, but it is important that the bands shall be large enough, or the deposit is apt to be retarded; better have them too large than too small.

The surface of the depositing trough must be perfectly free, hence the conductors should be so secured as not to interfere with placing the moulds. A 9-in. board may be first fixed to the wall at the back of the trough and battery, and the copper bands screwed flat to it until they reach the point where the connections are made. When electrotyping is done on a large scale it is advisable to have more than one connection from the battery, so that the current may be of uniform strength throughout the solution. After the first connection is made, the conductors are carried along to the centre of the trough, where the second junction can be effected. If the depositing vat is large, and this plan is not adopted, the deposit is liable to be thicker and more rapid at the end than in the centre of the solution.

For supporting the moulds and copper plates in the depositing trough, rods $\frac{1}{2}$ in. in diameter are used, slightly shorter than the width of the trough, so as not to hang over, or they will interfere with the workman; they are commonly made of brass, but copper is more durable, as the zinc in the brass quickly becomes affected, and after the rods have been a little time in use, corrosion sets in.

Copper binding-screws are employed for securing the zinc plates and connecting the wires. The moulds are hung from the rods in hooks of copper wire about $\frac{1}{4}$ in. thick, well turned up at the ends, to admit of the moulds being moved without slipping off. A thick deposit of copper will form on the ends of the hooks if they are allowed to touch the solution, and must be removed with emery paper or a file; the copper rods may be cleaned in the same way.

Be sure always to have a good supply of water in the battery room; also a lead-lined trough beneath the tap. At one end of the trough, fix an inclined board, covered with sheet lead, on which to clean the moulds before putting them into the trough. A useful accessory is 12–18 in. of rubber pipe, with a fine rose at the end. Nail a fillet along the outer edge of this board to keep the water from running on the floor.

The metal pot is rectangular in form and usually rather large, to admit of the backing-pans being lodged on the surface of the metal with little difficulty. Fumes from the molten metal may be carried off by suspending a large sheet-iron funnel immediately over the pot, and providing it with an outlet into a flue or chimney. The pans may be either lifted by hand on to the metal, or swung from a suspended framework,

on which a small carriage can travel, about 4 ft. above the pot.

The iron backing-pans are of a size to accommodate 2 demy-4to shells, with a handle at each end for the hooks on the travelling carriage to hold by. But the backing of shells, in almost all instances, is done by placing the backing-pan, containing the newly-tinned shell, on the iron surface, and pouring metal from the ladle.

Besides the melting pot for wax for "building" purposes, another must be provided on a separate bench for "stopping-out" the back and those portions of the moulds where no deposit is required. An iron or leaden slab should be placed near, on which the moulding pan can rest, and on which the superfluous wax may run; the latter can then be easily scraped from the surface and replaced in the pot. A wooden balk is liable to become quickly indented by the moulds, and the wax, filling the holes thus made, renders the task of cleaning more difficult. A brush, similar to that used for blackleading grates, is employed for "stopping-out." Waste wax and dross from the melting pots, which may contain a small percentage of copper, should be collected and sold.

Preparing the Forme.—If high spaces have not been used by the printer, the pages must be floated in plaster of Paris in the same manner as described on p. 219.

Work for electrotyping is generally sent to foundry imposed in small chases; 2 or more 8vo pages may be placed together, with type-high furniture between. If screw chases and type-high furniture, already described, have not been used, the forme must be "dropped" upon the imposing surface, and reimposed, first carefully examining on the inside, that no dirt be adhering.

When the forme is screwed-up, the face of the type is well brushed over with lye, to remove dirt from the beards of the letters, then dried and planed thoroughly, taking care that all the spaces are pushed down. Next the type is brushed over with graphite, until the surface is perfectly bright; this assists in the separation of the wax when lifting, after the impression is taken, and to some extent it ensures the graphite finding its way into all portions of the mould.

If there are wood-blocks in the type, the page should be examined to ascertain whether they are of the same height as the type. If not, they must be underlaid with glazeboard. Turpentine should be used for cleaning wood-blocks prior to moulding, as it causes no warping. After blackleading, be sure that no dust remains on the surface.

Preparing the Moulding Pan.—Meantime the moulding-pan will have been filled with a composition made by mixing 20 lb. beeswax with 3 lb. Venice turpentine and ½ lb. graphite, keeping it perfectly free from dirt. Several frames at once are laid upon the iron imposing-surface and filled to the level of the sides of the frame; if it sinks on cooling, more is added till the frame is full. Any that flows over the sides speedily solidifies, and may be put back into the melting pot. Air-bubbles must be carefully and quickly removed. As the wax rapidly becomes solid, the pouring should be performed as speedily as possible; if allowed to become thick, the surface will not be level. Should the wax seem inclined to crack in cooling, owing to a low air temperature, a little more Venice or virgin turpentine may be added.

Moulding.—As soon as the mould and forme are ready for moulding, pull the table of the press forward, so as to allow of the pages being properly placed in the centre, and wipe it perfectly clean. Before putting the moulding frame on again, carefully examine the surface of the type to ascertain if it be quite clean. Taking the moulding frame, one end in each hand, lay it face downwards on the forme, so that the impression will be taken in the centre of the wax. Pressure is applied till the required depth is obtained, as determined by experience. If the mould is not deep enough, the work of the finisher is greatly augmented, owing to

the extra amount of "building-up" required; if too deep, the face of the mould is apt to be torn when lifted.

After the pressing, the wax will be found to be forced out unevenly all round the edge of the moulding frame. Raising the mould from the forme is the most difficult operation, performed by the aid of 2 pieces of flat iron about 1 in. wide and ¼ in. thick, fitted into handles, with the ends turned up, the bend resting on the chase or furniture, forming a lever. The irons must be placed under the head and foot, and on no account should the sides be attempted first, or the wax will be torn from between the letters; when the mould is loosened, the sides may be slightly and very gently raised, or the wax will tear. When every part of the mould is disengaged, the frame is taken by the head and foot, and perpendicularly lifted from the face of the forme. If perfect, it is ready to be prepared for the depositing trough.

Clay dispenses with the assistance of a press, and obviates the necessity of floating low-spaced formes prior to taking the impression in wax, by using a thick iron "registering-frame," slightly higher than the chase, fitted inside with 2 long set-screws at right angles, with somewhat large heads, and an ordinary Albion press with the tympan removed. The register-frame is placed on the bed, and blackleaded, the forme is placed inside. The face of the type is covered with a piece of calico; on this is laid a thin piece of rubber sheeting, then the pan containing the wax, care being taken to push the sides of the pan flush to the set-screws in the register-frame. On pulling a light impression and lifting the wax, it will be found that the "whites" have been almost sufficiently raised. The rubber and calico are next discarded, and the wax-pan is placed directly on the type, the edges of the pan being pushed close to the heads of the set-screws to ensure the wax falling exactly in the same place. If a moderate impression is pulled, the mould will be found sufficiently deep and sharp, equalling one produced by a press. In the case of type electros, this plan possesses the advantages of being quicker, less troublesome, and saving in time and material.

Greater difficulty is experienced in moulding open or rule work than with other kinds of formes; the pressure must not be too severe, or it is probable that the mould will be torn in separating. Brass rules for work to be electrotyped are specially made with a wide shoulder, which prevents the rule itself cutting too deeply into the wax.

For moulding casts taken from electroplates, an iron slab about ¾ in. thick should be provided as a bed on which the plate is supported on the table of the press. Mounted electros should first be removed from the wood, as the block may be "spongy" or uneven, by forcing a thin chisel between the plate and the wood.

In separating the plate from the wax, the plate is lifted from the wax by laying the moulding frame on its back, and inserting a thin chisel between the wax and the electro, gently raising at the head and foot till thoroughly loosened, when the sides may be treated in the same manner. Moulding from an electroplate of a cut is rather more difficult than from a wood-block, as the fine work is invariably shallow. If great care be not taken in the examination of the mould, when the plate is finished it will be found necessary either to repeat the process or partially re-engrave the work.

Building.—The moulded wax impression is handed to the "builder," whose duty is to remove the superfluous wax from the sides, neatly trim them, and "build-up" the low parts or "whites" in the page. The amount of work required in finishing the plate greatly depends upon the manner in which this operation is performed. The wax that has been forced out round the edges is cut away with a knife, as low as the edge of the moulding frame will permit. Then molten wax is run into the hollows, such as the quad lines in paragraphs, the spaces on either side of the title and at the head of the page, to

ensure these portions being sufficiently low in the shell to prevent them blacking in the printing, as of course the higher these spaces are raised on the mould, the deeper they become in the electro.

A handy tool for stopping out small spots is made by twisting copper wire round a short stick, the ends being allowed to hang over the end. The wire on the body of the stick is warmed, and when sufficiently hot, a piece of wax is pressed against it; on inclining the point to the desired spot, the wax will run in.

The wax melting pot should be near the "builder's" hand. As the wax solidifies immediately it is taken from the pot, especially in cold weather, the knife must be kept hot by holding it in the gas-flame before taking up the wax. With the warm knife, lift a small portion of the liquid from the pot, and slightly decline the point in the hollows, moving the knife with a rapid but smooth motion above the parts to be built up. Great nicety and steadiness are required in doing this: if the wax is too hot, it will flow too freely, and probably run on to the impression; if it becomes chilled, it will be sluggish and run unevenly.

Fragments of wax that may be found on the top of the spaces must be removed, but unless done in a clean and sharp manner, will cause an ultimate defect; they may, however, sometimes be softened down by passing a gas-flame *rapidly* over the entire surface of the mould.

If low spaces have been used, and the forme has not been floated prior to moulding, the work of the "builder" is greatly augmented. The removal of the wax spaces becomes a long and tedious job, and the risk of spoiling the mould is considerably increased. A sharp flat knife, slightly warmed, should be used for the purpose, and the pieces cut away uniformly. But it is never advisable to take a mould from a low-spaced forme (except by Clay's process), as floating takes less time than removing the wax from the spaces.

Blackleading.—Wax being a non-conductor of electricity, it is necessary to cover the surface of the mould with some substance that is not only a conductor, but can be applied without distorting or damaging the wax. Graphite or "blacklead," as it is more commonly called, is not only an excellent conductor, but can also be easily and safely deposited on the surface of the mould.

The graphite must be perfectly pure, well ground, and free from grit. If it is not, the surfaces of the moulds are liable to be scratched or otherwise injured in the brushing. The best plan is to sift it through a very fine gauze sieve prior to using. No metallic deposit will take place except on the spots coated by the blacklead. Brushing the mould with blacklead prior to making the mould, somewhat assists the operation, but the pressure forces up to the surface a quantity of wax which must also be coated.

The conduct of the operation of blackleading has been already described on p. 210.

The blacklead is entirely removed from the surface, which should be gently polished by the goats'-hair brush, until it attains a bright metallic lustre.

Stopping-out.—The mould is next "stopped out," by brushing liquid wax on those portions of the frame and wax upon which no deposition is intended to take place. With a brush dipped in the liquid wax, thoroughly cover the back and sides, and that portion of the front that is not impressed. It is also necessary to exclude all the minute air-bubbles that are probably attached to portions of the face of the mould. If this were not done effectually, the shell would be ruined by minute perforations. It is performed by placing the mould face upwards in a pan, covering it with about 3 in. of water, and directing streams of water on to the mould through the rose. The operation also removes any remaining particles of graphite. It is a good plan to add a little alcohol to the water, as it has a

great affinity for the wax, and in the action of rising to the surface displaces the air.

The Deposit.—The mould is now ready for immersion in the battery trough.

A full account of the electro-depositing process will be found in 'Workshop Receipts,' First Series, pp. 170–235.

Galvanic batteries and dynamo machines are also described in 'Workshop Receipts,' Third Series, pp. 117–38.

A substantial electrotype or shell should be obtained in 10–15 hours. To test the thickness of the shell, the mould may be lifted from the solution, and a corner of the copper slightly raised from the wax by a knife. The usual thickness is about $\frac{1}{32}$ in. When properly backed, any number of impressions may be obtained from such a plate. A thin shell is more secure on its backing than a thick one; being light in texture, it is better able to adapt itself to the metal. If, when the mould is taken out, the deposit is found not to be sufficiently thick, rinse it well in water and replace it till done; then wash it in cold water, lay it on the inclined board near the sink, and pour hot water on the back, when the copper will immediately disengage from the wax. If, on holding the plate up to the light, many holes are seen, the defect may generally be attributed to faulty blackleading, and a new electro will have to be taken; if there are but few, the plate may be repaired by the picker when finishing.

A number of shells may be backed at one time, and sufficient metal should be in readiness. As the backing metal and the copper shell have no affinity for each other, it is necessary to employ a medium to unite them. Granulated tin, mixed with lead, is generally employed. Take equal parts of lead and tin, and when in a molten state pour the metal through a fine gauze net, allowing it to fall into a pail of water.

The backing-metal is made by melting together 91 parts lead, 5 of antimony, and 4 of tin. Less antimony is used than for stereotype plates, because it has a great affinity for tin, and has a tendency, if in too great a proportion, to take it up from the shell. The "peeling" of the shells is sometimes owing as much to this cause as to an insufficiency of granulated tin. Backing-metal can be bought ready made.

The backing-pans are allowed to rest on the surface of the metal pot until they are hot, before placing the shells in position. Meantime the latter are arranged on the iron surface, and any tendency to curl at the sides or ends may be cured by laying stereo-clumps on the edges. With a stiff brush cover the back with muriatic acid, and sprinkle so much granulated tin as will, when melted, cover the entire surface. To muriatic acid used for soldering must be added $\frac{1}{3}$ water, and as much zinc (amalgamated) as it will take up; also a little borax or sal-ammoniac.

Lowering the shells in the backing-pan on to the surface of the metal, the tin soon melts, covering the whole of the shell with an even film. Wherever it fails to touch, a piece of solder must be applied, as the metal will not adhere in the bare places. The copper must not be allowed to become superheated, or it will oxidise.

The shell being properly covered with tin, skim the dross from the surface of the metal, and test the latter as described on p. 220. Pour metal on the shells, commencing at one corner, and gradually advancing over the entire surface, until the necessary thickness is attained. Set the pan aside to cool, when the plates can be taken out and placed in racks ready for finishing. Any small pieces of metal found between the lines, or between the hollows of the letters, may be easily removed with a bodkin.

Trimming and Bevelling.—A good plate should be perfect on the surface, level on the back and front, square, and have bright, clean, and accurately-bevelled edges. On being taken from the pan, it is trimmed as close as will leave sufficient metal to form a good bevel. If several are backed together, they are separated by the circular saw before trimming. Any depressions or "sinks" must be marked

with a pair of callipers, properly adjusted to the thickness of the plate; then lay the plate face downwards on a clean smooth iron surface, and with a polished and flat-headed hammer beat the places carefully. Practice will soon enable the ear to distinguish when the spot has been beaten up to the level of the slab, by the hard metallic sound. Next, with a small planer 3 in. square, plane the back all over, when the plate will be ready for the lathe, as described on p. 222. It is not necessary to put paper between the face of the lathe and the plate, as the copper is sufficiently tough to resist injury with fair usage, and can be better secured without. The knives should take off sufficient metal to reduce the plate to within a thick lead of the thickness ultimately required.

All superfluous metal is sawn off, allowing a margin 1 great primer in width from the edge of the type. The plate is then ready for the planing machine, where it is finally reduced to standard thickness, as described on p. 222.

The bevelling may be done either by hand or on Manley's machine. If the latter be used, trimming is unnecessary. In bevelling by hand, the knife should be sharp, in order that the cut may be clean; steadiness of motion in working should be aimed at. The metal may be easily taken off with an ordinary amount of care.

Mounting.—If the electro is to be mounted on wood, the bevel need only be sufficiently wide to afford a substantial hold for the pins. Mahogany is the best wood for mounting on. A quantity should be purchased and stored in a dry place, so as to become thoroughly seasoned before use. The block must be a trifle thicker than is absolutely required, to admit of trimming down in the lathe, a gauge being kept for the purpose. French pins with very small heads are best for fastening the plate to the wood. After fastening the sides, one or two nails should be driven into the body of the plate, in the "whites." It is almost impossible to repair the surface when the plate has once been fastened on the wooden mount.

Picking.—The picker works at a bench placed in a well-lit position, supporting a leaden slab, about $\frac{1}{2}$ in. thick and 12 in. square, with a small rectangular hole near one corner for use when punching. A double gas bracket is fixed at the back of the bench, one arm being for lighting the workman, and the other to supply gas for his blowpipe apparatus.

The picker's first duty is to chip down the "whites" of the plate, so that they shall not take the ink in printing. Where much work is done, this process is performed by a routing machine with vertical steel cutters.

The next object of attention will be injuries to the working surface of the plate. A battered letter may sometimes be repaired by forcing up the sides of the injured part, making a small hole underneath with a fine bodkin, and then forming a firm line. If a word or letter be much damaged, types must be inserted, thus:—

Lay the plate on its back, and with a small chisel cut away the letters as deeply as possible; bore a hole through the plate, that the exact spot may be indicated on the back; turn the plate on its face, and cut away the metal until a hole is made almost large enough for the type; file the perforation to the proper size, ensuring that the hole is exactly even with the line of the plate; push the letter in from the back and carefully examine that it be in its proper position. The hole should not be made larger than is absolutely required, or difficulty may be experienced in fixing the type for soldering; in that case, the type may be temporarily secured by forcing a portion of the metal of the plate on one side or the other by the bodkin. When the letter is properly in position, tap it on its end, and the plate on either side, to ensure its being exactly of the same height as the surface; then saw the protruding body of the letter away flush to the back of the plate; again examine it on the surface,

to make sure that it has not been shifted in the cutting; then scrape the metal around the insertion, apply a little dilute muriatic acid, and melt the solder on the place by the blowpipe, removing superfluous solder with a rasp. Many hints on soldering will be found in 'Workshop Receipts,' Third Series.

When electros of cuts are soldered to a plate, or inserted in the text, in stereotypes or electrotypes, great care is required in joining the metal that the soldering be thoroughly done.

Before repairing batters at the edges of a plate, it is a good plan to solder a piece of metal along the side to support the type, taking it away after the letters are properly secured.

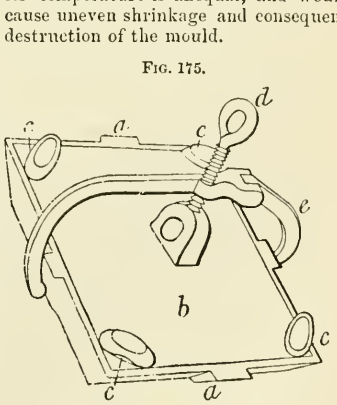
Gauging Mounted Electros.—Mounted electros should be cleanly planed along the sides and edges by the block and plane. For adjusting them to their proper height, a long plane is necessary, the box of which should be about 3 ft. long, the knife being nearly in the centre. A shooting-block must be made, with raised pieces of wood at either side, and exactly type high, which is tested by passing it under a gauge consisting of an iron slab, having a kind of bridge in the centre, the exact height of type. If the block is higher, place it face downwards on the shooting-block, securing it on either side by wooden wedges; then take a shaving off the back by the long plane, the ends being allowed to rest on the side-supports, which prevent too much being taken off. Electros should be mounted rather low than otherwise.

STEREOTYPING.—When matter has been set up in type, it is often desirable to reproduce it in a form more convenient for handling, while at the same time liberating the type for further use. Hence has arisen the art of stereotyping, or reproducing the type surface in solid plates of metal. There are two methods in which this is performed, differing essentially in the material forming the moulds. They are known respectively as the Plaster and the Paper processes.

Plaster process.—In this, the older but less adopted process, the moulds are formed of plaster of Paris. Among the advantages of this method are that the castings produced have much sharper and deeper outlines; on the other hand, the mould is destroyed in releasing the casting, and the operation occupies a longer time and is more expensive.

Apparatus.—The metal-pot, of a convenient size for immersing the dipping pans, is best fixed against a wall, to facilitate handling the pans by means of a crane. The oven for baking the mould may adjoin the melting pot, and be fitted with several shelves. A good arrangement is an ordinary low brick furnace surmounted by a square oven about 3 ft. wide and 4–5 ft. high, bricked in, and having the furnace flue carried round the back and sides. The door covers the whole front of the oven, and an iron shelf 8–10 in. wide, is fixed beneath it on a level with the bottom shelf, for convenience in sliding the articles in and out. The floor of the oven should be reserved for heating pans and plates before casting, and never for baking the plaster moulds, as its temperature is unequal, and would cause uneven shrinkage and consequent destruction of the mould.

FIG. 175.



The plates are cast in dipping pans (Fig. 175), 3–4 in. deep, oblong, and with sloping sides, on which are sockets *a* to admit the clamps by which

the pans are swung from the crane. The cover *b* may be flat or slightly domed, the corners *c* being cut off to admit the metal. The lid is held in place by the screw *d* and the hinged clamp *e*. The floating plate, of $\frac{1}{2}$-in. iron, fits loosely into the dipping pan.

The trough for cooling the dipping pan and its contents is placed beside the metal-pot, in a position to admit of the crane easily depositing its charge. It should be about 4 ft. long and 2 ft. wide, and stand slightly below the top of the metal-pot; 4 iron bars, $\frac{3}{4}$ in. thick and 2 in. wide, are fixed across, sufficiently near each other to allow of 2 dipping pans being placed on them at one time. A few pieces of thick flannel, or similar substance, secured round the bars will admit of the moisture being communicated gradually to the hot pan. Some molten metal frequently falls into the trough from the corners of the dipping pan during suspension, and from the ladle while filling; the trough should be cleaned up at intervals, and the cleanings thrown into the metal-pot, but not while the metal contained in it is heated. A good plan is to sweep the foundry and clean out the cooling trough every night, and to transfer the sweepings to the metal-pot, ready for melting on the following morning.

The plaster matrix is taken from the forme in a moulding frame, which in appearance bears a close resemblance to an ordinary chase; but the 4 sides facing the type are bevelled inwards, so that when the plaster hardens it is equally supported on all sides.

The formes are placed for moulding on an iron surface fixed against a wall. It should be long enough for several moulds to be prepared in immediate succession. The iron surface may be replaced by a slab of stereo metal, 1 in. thick, well planed on the surface, and arranged along an ordinary wooden balk; in this latter case, the surface of the slab should be frequently examined, to ascertain whether there are any indentations, which would necessitate their being either replaned or discarded, as the type might sink into the cavities when planed down, and render the mould imperfect.

The dipping pan, after cooling, is placed on a block 4 ft. high and 3 ft. wide, where the mould is knocked out of the pan, the corners of the cast are detached by the mallet, and the plate is thus set free.

Brushes are needed for cleaning the type, removing the plaster from the surface, and oiling; small steel straight-edges, for taking off the superfluous plaster from the back of the newly-made mould; chisels, for raising the moulding frames from the forme, and releasing the plate from the metal; a strong barrel, with lid, for the storage of the plaster in a dry place; and several tin cans for mixing the composition.

Preparing the Metal.—Several recipes for the composition of alloys for casting stereotype plates will be found in 'Workshop Receipts,' Third Series, p. 33. In general terms it consists of lead with about 12–18 per cent. of antimony added to produce the necessary degree of hardness. It may be bought in blocks ready for use, which is the better plan in all but large establishments, as some skill is required to ensure making a good quality of metal, and without that quality satisfactory work is impossible.

The furnace and pot for melting the metals and making the alloy, as well as for heating the metal ready for casting, should be completely encased in a hood of sheet iron, with a flue leading from the top, which flue may be utilised for conveying a certain amount of heat to the drying oven. The hood must have a door in the front to permit the metal to be stirred, skimmed, and ladled out.

Before making the alloy, the lead is melted alone first, and thoroughly freed from the dirt and dross which collect on the surface, by means of a skimmer, consisting of a disc of perforated sheet iron with a rim and short handle. The addition of a small quantity of oil or grease to the molten metal will much facilitate the liberation and removal of the dross. When the lead is perfectly

clean, it is cast into blocks ready for remelting to make the alloy.

In conducting this latter operation, the lead is again placed first in the pot, melted, and well skimmed, taking especial care that no zinc is allowed to contaminate it. When quite clean, the proper proportion of antimony is added, that being, for every 100 lb. of lead, 18 lb. for the plaster process, but only 12 lb. for the paper process. If the molten alloy, after being well stirred to mingle the two metals, be found to exhibit a tendency to adhere to the sides of the pot and to the tools plunged into it, this may be taken as a sign of poor quality and the necessity for adding more antimony. Having secured a good quality of metal, it will be fit for casting at about 600° F. (316° C.). Experienced workmen estimate the temperature by holding the hand at a distance above the pot, instead of having recourse to a pyrometer, but a novice would need to resort to the more scientific method until accustomed to judge of the heat.

In making stereotyping metal in the foundry, a quantity should be mixed at one time, as the plaster process demands much material always in use. The manufacture of the alloy considerably interferes with the casting, and the dipping should never be commenced without a sufficient supply being available. In most foundries where mixing is carried on to any extent, a separate pot is provided for the purpose, taking care that it is well closed in by an iron hood, before described, just sufficient opening being left for the long iron for mixing.

The broken metal, if of good quality, should present a sparkling appearance; if it is dull, sufficient antimony has not been added, and plates made from such metal will lack sharpness of outline.

Preparing the Forme.—The first step is to subdivide the forme, if possible, so as to have plates of minimum size. The forme is laid on the imposing surface, unlocked, slightly damped, and re-imposed in smaller chases with type-high clumps to replace the furniture round the pages, noting that the lower side of the clumps must come next to the type. Every precaution must be observed to prevent types falling out, and to ensure the matter being securely locked up and level.

Low spaces and quads must all be raised to the level of the height of the shanks of the letters prior to moulding; therefore it is desirable to employ high-spaced founts when plaster casts are to be taken. Besides being originally more costly, however, the high spaces would be a source of much trouble if the type should be required for working from.

"Filling-up" is effected by pouring plaster having a pasty consistence over the surface of the forme, and rubbing it down by hand. When this has been evenly and thoroughly performed, and before the plaster has completely set, the whole is gone over with a moderately stiff brush, to remove the plaster from the beards of the letters.

The pages having been examined for imperfections, the forme is set to dry thoroughly in a rack specially provided. If a number of formes are to be cast, it is well to fill them all at one time. The plaster being dry, the forme is laid on the imposing surface, which must be perfectly clean, and the face is again brushed, so that any small detached crumbs of plaster may be cleared away.

Before oiling, it is absolutely essential that the face of the type be both clean and dry. When this is the case, carefully apply some olive oil on a soft brush, sometimes adding a small proportion of turps if the oil is very thick. The oil must adhere in every part, or the cast will come away in an imperfect condition—pieces of plaster remaining attached to the unoiled spots. The oil answers a double purpose, preventing the adhesion of the mould to the type as well as hindering the moisture of the fresh composition from affecting the plaster already used in filling-up the forme.

Casting the Mould.—On the locking-up furniture round the type are placed pieces of tin about 1½ in. wide and of various lengths, destined to provide a

perfectly flat surface for the casting frame, and to stop the thin plaster from running. The casting frame is adjusted in position round the pages, after the sides have been oiled. Then, in an iron or tin pot kept for the purpose, is mixed a sufficiency of plaster to a creamy consistence; this is poured upon the face of the type, and carefully forced in by a pad of folded blanket, called a "dabber." In this way the air is expelled from between the plaster and the face of the type. Then more pasty plaster is added, and well rubbed in by hand, to ensure the plaster occupying the smallest interstices, when the surface of the type will be completely covered with a film of plaster.

Next a further quantity of the composition is mixed somewhat thicker, and enough of it is poured on the forme to entirely fill the casting frame. As the plaster hardens very rapidly, every means must be taken to prevent small lumps from forming, both on the hands and in the mixing pot; after each operation, the hands and pot should be well washed. Whilst the plaster remains liquid, the surface is scraped with a straight-edge level with the top of the casting frame, after which the mould is allowed to stand for 5 minutes; by this time, it will have partially hardened, when the back may be scraped again. Should the mould not be of uniform thickness throughout, it is apt to be cracked by the pressure of the molten metal in the dipping pan. Success is almost entirely dependent upon the quality and manipulation of the plaster.

Removing the Mould.— When the mould has stood some 15–20 minutes, it should have become sufficiently firm for lifting from the type. Forked tools with short handles are used for this purpose, one in each hand, the points being carefully inserted between the casting frame and the chase. The operation demands the gentlest care; if force is exerted unevenly, small portions of plaster will break off and spoil the mould. After detaching one end of the frame, the other end is loosened in the same manner; then the whole can be lifted off the forme, being supported by the protruding bevel of the casting frame. After removal of the mould, the type should present a perfectly clean face, not a particle of plaster appearing among the type.

Baking the Mould.—When the mould has stood for a few minutes, with the aid of a knife cut a small groove round the back, towards the iron frame. Turn the mould on its back, and lightly tap the frame, when the plaster will drop out in its entirety. Superfluous plaster is trimmed off with the knife, and notches are cut on the top sides of the plaster rim, that the molten metal may gain admission to the face when put into the dipping pan.

The plaster cast is next baked in the oven, whose proper heat is about 400° F. (204° C.). The mould is introduced between 2 of the partitions in the oven on its side, and allowed to remain for about 1½ hour, by which time it will have become sufficiently baked, and will assume a brownish hue. Meantime the dipping pot and floating plate are likewise put into the oven, on the bottom shelf, in order that they may attain the same heat as the mould.

Testing the Metal.—Before pouring, it is necessary to test the metal, as unless it is hot enough, it will not flow freely under the cast, and the plates will lack sharpness or become chilled; if too hot, the mould is liable to crack when immersed. The test mostly applied is that of inserting a piece of paper in the metal, when the paper should acquire a straw colour. If the metal is too hot, the draught of the fire must be reduced or a little cold metal added. The dipping pot or casting pan, when sufficiently heated, is slid along the iron shelf to the front of the metal-pot, and the floating plate, which is of the same size as the bottom of the pan, is put inside, the workman being provided with pads of thick flannel while handling them.

Casting the Plate.—The first precaution is to ensure that the pan, plate, and mould are of nearly one uniform temperature: if the plate is colder than the cast it will cause a sudden contraction

of the latter; if warmer, a sudden expansion, either of which will probably crack or warp it. Some workmen prefer to heat the floating plate by immersion in the molten metal. There must be no delay between placing the dipping pot in position, the floating plate inside, the mould on the top, and fastening the lid. After removing the cast from the oven, should anything unforeseen occur to prevent its being immediately placed in the dipping pot, it must be put back in the oven till heated again, together with the pot and plate.

Should the cast be much smaller than the floating plate, small plaster cubes, previously prepared, may be placed round the sides, to prevent it moving about in the pan. The cover is next put on and secured by means of the clamps and screw, the clamps attached to the chain on the crane being fastened into the sockets on the side of the pan. The ratchet is wound up and the whole is swung above the metal-pot, then gently lowered until the top is on a level with the surface of the metal. By tilting the clamps with one hand, the side of the dipping pan is gently dipped at one corner into the metal, allowing the latter to flow in only at one corner, so that the air may be driven out at the other openings, the pan being entirely immersed only after all the air has been expelled. When the pan is full, gently lower the whole into the metal, allowing it to rest on the bottom of the pot. Care must be taken that the metal in the melting pot is not allowed to run too low, so as to ensure that when the mould is placed ready for dipping, there is sufficient metal to cover the top of the pan.

When new metal is added to the pot, the temperature of the mass will be considerably lowered, and no cast should ever be made without first testing the temperature.

By its greater specific gravity, the molten metal presses up the floating plate and the mould to the lid of the dipping pan, and forces itself through the notches cut in the side of the plaster into every part of the mould. The pan should remain in the metal for about 10 minutes, during which time the floating plate for the next casting may be placed in the metal, allowing sufficient to remain above the surface to enable the operator to obtain a firm hold for its removal.

Cooling the Cast.—When the pan has remained in the metal for the time stated, it should be gently raised, swung round to the cooling trough, and allowed to rest on the supports made for the purpose. Care must be taken that it be swung in a perfectly horizontal position, or the metal will be liable to flow to one side and thus render the thickness of plate uneven. As the metal cools, it contracts considerably, and more metal must be poured in at the corners of the dipping pan, to make up the deficiency, and to exert the necessary uniform pressure on the cast. This pouring must be repeated several times during the cooling. As the water in the trough sinks owing to the rapid evaporation, further supplies should occasionally be added to maintain the required level. The cooling of the cast (which properly occupies about 20 minutes) must not be hurried, or the mould will split, and the metal will run into the crack. If the cooling operation is hastened in the slightest degree, the sudden contraction of the metal on the surface of the newly-formed plate will cause the letters to lose their clearness of outline. The water in the trough should be high enough to saturate the pieces of blanket, but it must not be allowed to touch the pan bottom.

Knocking-out the Plate.—When the pan has completed its cooling, it is lifted on to the knocking-out block; then loosen the clamps, and remove the lid by inserting a strong chisel at the corners. Turn the pan upside down, and give a smart blow with the mallet on the bottom, when a block of apparently solid metal will drop out. Let it stand for a few minutes to allow it to become still colder, then turn again, the widest part uppermost. When the metal is sufficiently chilled, strike off the extreme corners with a mallet, being careful to hit away from the bulk. Next break

away the sides, striking from the top, and, as before, away from the body of the metal, or the plate will be injured.

After all the edges round the top are struck off, the thin metallic covering of the mould can be removed, and the whole of the plaster will be exposed to view. This can be picked from the surface of the cast, and the latter be lifted from the floating plate.

It is wise to wear a leather apron, to provide against the effects of metal splashing; some thick blanket-pads should be provided to enable the workman to safely handle the hot dipping-pans, floating plates, &c.

Should any plaster adhere firmly to the detached pieces of metal, the whole may be thrown into the melting pot, when the plaster will rise to the surface, and can be skimmed off with the ladle.

If the cast is perfect, superfluous metal is cut away and the plate finished. More work is entailed in finishing a plaster plate than in the paper process, incurring additional items of expense.

Flattening the Plate.—In consequence of the unequal contraction of the metal on the face and back of the cast, before finishing in the ordinary way, the plate needs to be "flattened." Having trimmed the superfluous metal from the sides, &c., run a small straight-edge over the face, when indentations may easily be seen. Mark these places with a pair of callipers on the back, and then with a planer or burnishing hammer knock them up to the required height. A piece of thick brown paper or thin flannel must be placed between the beating surface and the face of the plate, or the latter may get injured.

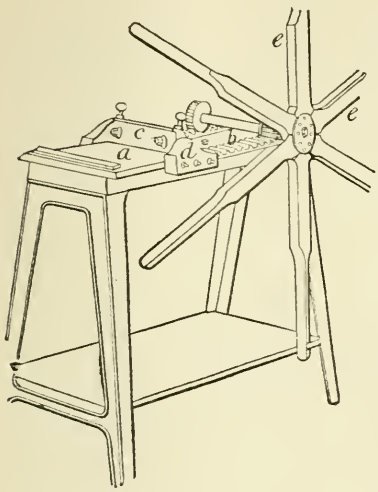
Turning to uniform thickness.—The back of the plate is sure to be somewhat rugged, and probably extremely uneven. It is therefore necessary, before planing smooth, to turn the plate to a uniform thickness, in a lathe made specially for the purpose. This consists of a large thick disc, working on a short shaft; 4 adjustable toothed chucks or "dogs" lie upon the surface, and can be moved to any position towards the centre of the disc by the turning of a screw-head in the flange of the wheel. In front, and parallel with the disc, is a slide, upon which is fastened a carriage provided with adjustable knives. After the plate is fixed to the large disc or wheel by the chucks, the machine is set in motion, and, as the plate revolves, the carriage and knives move slowly along toward the centre of the disc. By this means, a regulated thickness of metal is taken off, in circular strips. A piece of thin brown paper is laid between the faces of the disc and the plate, to prevent any injury to the latter by rubbing when it is being secured. When fixing, it is essential to place the plate as near the centre of the wheel as possible, and to tap or press it closely to the surface; if this be neglected, it may be springy when screwed up, which will cause the metal to be taken off to an unequal degree. On the other hand, the chucks must not be screwed up too lightly, or the same defect will occur, and the plate be insecure. Just sufficient force should be exerted in securing the plate to prevent the possibility of its being jerked off while being turned.

Planing the back.—Before placing the turned plate in the planing machine, the angles of the top and bottom edges of the back of the plate need filing off a little, so as to enable the plane to catch the metal fairly. The machine must be adjusted with accuracy so as to reduce the thickness of the plate to a small pica, always allowing for the sheet of paper which must be interposed between the face of the plate and the bed of the planing machine. This planing process is not always carried out, but its advantages are obvious in saving labour when the plate has to be made ready for printing from.

A handy form of planing machine is shown in Fig. 176. It consists of a long iron bed *a* working backwards and forwards on a long screw *b* running beneath. The knife *c* is fastened at a slight inclination in a frame *d* fixed across the centre of the bed. The plate is laid face downwards on the bed, and a thick iron wedge is forced by the workman on the

back of the plate. By revolving the capstan wheel *e*, the plate is gradually driven under the knife, by which a slice of

FIG. 176.



metal is taken off and the plate reduced to a uniform thickness and even surface.

Bevelling and Squaring the Plate.—The planing has rendered the plate true as regards its faces. The next step is to adjust its edges. An accurate gauge should be used, each size of type page requiring a separate gauge. The plate is laid on a flat narrow iron table, arranged to run on slides, fixed to a very firm bench, with a planing iron secured in juxtaposition. The plate is laid on its back and covered with a piece of stout blanket, on which a screw platen descends to hold it in position. The plate having been correctly gauged, the edges are accurately planed off to the gauge, and then as carefully bevelled at the margin. Where operations are conducted on such a large scale that hand labour would be inadmissible, some form of planing and bevelling machine may be used, such as Hoe's or Manley's. These operate by means of revolving cutter discs, a hood being fitted over the work to collect the flying particles of metal. A small gas engine or water motor is handy for driving the machines.

Mounting the Plate.—If the plate is to be mounted on a wooden base, the bevelling can be dispensed with, the plate merely requiring to be trimmed square and almost flush with the type. The best wood for mounting on is well-planed pine; the plate is thoroughly secured by driving ½-in. French nails through the metal and into the wood, punching them down flush with the metal.

Stereotyping has been largely adopted in newspaper work as saving much labour where the same item of news has to be sent to perhaps a dozen or more different papers. In this case, plates of the items are cast in the required number, and distributed. To reduce the heavy cost of transport entailed by using the ordinary massive plates, the impression is taken in sheets of metal of only just sufficient thickness to afford a printing surface and ensure freedom from liability to breakage by rough handling. Then this metallic printing surface, which will be recognised as the essentially valuable part of the stereotype plate, is mounted either on wooden lengths, of the proper thickness, and secured by nails; or recourse may be had to the metallic block system, as introduced by Cassell & Co., in which the plate is cast with an undercut projection corresponding with a groove in the block which is to make up the necessary type height. The blocks are cast in columns, and afterwards cut into pieces varying from ½ in. to 18 in. in length, for convenience of making up into columns. The plates are locked to the blocks by column rules. Obviously the same principle may be carried out with any suitable method of uniting the plates and blocks.

It is a matter of convenience to cast the "risers" or movable blocks for mounting plates, on the premises. They are usually made square, with indentations at the sides for reception of the

brass catches, as in Fig. 177, which measures 3 in. long and 1½ in. square, other sizes being also made. The side clumps, Fig. 178, are made either 1½ or 3 in. long, and 1 pica thick. The blocks should be cast hollow to save metal. The catches, Fig. 179, are made of brass rule, and can easily be produced on the premises, by getting long strips cast with the required flange, then cutting up as needed, filing quite smooth, and drilling the necessary holes for admitting the pin that holds all secure.

Fig. 177.

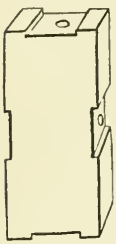


Fig. 178.

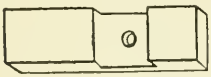


Fig. 179.

Perfecting the Plate.—After all the preceding processes, the plate is very carefully inspected for minor imperfections. Of course, anything like a serious imperfection is quite sufficient to condemn the plate entirely, and necessitate its being redone from the beginning; but small matters may be remedied. Among these are spots where the metal in the "whites" comes too high and would be in danger of taking the ink in printing; such must be chipped away with a sharp chisel. Again, individual letters may be battered; these require to be drilled out, a new type letter being dropped into the hole thus made, and secured by soldering from the back.

Moulding from the Plate.—Before taking a cast from a stereotype plate, its type surface must be very thoroughly cleaned with a brush and some strong soda solution, as for washing ordinary type, to remove accumulated dirt. It is then dried well, and the face is oiled, as in casting from type. The plate is next laid on the moulding table, tin side pieces being unnecessary. The mould is taken in the ordinary way, and when dry enough, it is turned on its back, and the plate is gently raised from it. Thus the mould is left till ready for trimming and the other usual processes that follow.

Plates taken in plaster suffer a much greater degree of contraction than those taken by the paper process, in consequence of the shrinkage of the mould in baking and dipping, while the type is not present to offer any resistance. The amount of shrinkage in a cr. 4to page is about 1 nonpareil in length and 1 thick lead in width.

Paper process.—In this process, which has largely replaced the plaster method, the mould is formed in paper pulp. It possesses great advantages in economy of time and material, enabling a mould to be taken and a plate cast and finished for the press in less than ¼ hour, and permitting a number of casts to be taken from the same mould, which may afterwards be stored for future use. The mould can also be curved to fit the semi-cylindrical casting box for making plates adapted to the cylinders of steam printing machines. In any case the process is eminently simple. Its chief drawback is that the plates never have such clean-cut outlines to the letters.

Composing the Flong.—The first operation in the paper process is the compounding of the "flong," a corruption of the French word *flan*, a sort of pastry to which the flong is supposed to bear some resemblance. The first requisite for making flong is some good paste, which may be either made on the premises or bought ready made. It must be moderately thin and of even consistence, i. e. quite free from lumps. Several recipes for making paste will be found in 'Workshop Receipts,' Second Series, pp. 98–100. There is nothing special about the paste for making flong except that it must be good.

Suitable paste being provided, it has to be applied to successive sheets of thick unsized paper, such as blotting or tissue, in the following manner.

Begin by covering a sheet of blotting-paper with a thin, even layer of paste, and place upon it a sheet of tissue,

rubbing it with the palm of the hand to render it smooth; care must be taken that all lumps have been previously removed from the paste. Next lay a sheet of blotting on the tissue, and roll flat. To this must be added 2 more pieces of tissue-paper, the whole forming a substantial flong. When a number of moulds are to be taken, it is advisable to make sufficient flong for the whole. When completed, and not required for immediate use, place the flong separately between damp blankets, with a board and weight on the top. This will keep them moist, and in a proper state for use for some considerable time. By this plan, the workman can finish one operation at a time, and confine his attention to each successive process. If the flong becomes dry, it must be discarded, for in this case it loses its virtue, and great difficulty will be experienced in obtaining a proper depth in the mould. Moreover, it is liable to crack in the heating.

Beating the Flong.—The forme having been properly planed level and carefully examined, slightly slacken the quoins. With the brush provided for the purpose, rub the surface of the type with olive-oil to prevent the matrix from adhering too firmly to the type. Cut the flong to the size of the page or pages, including the side and bottom clumps. Press it between blotting-paper to remove the superfluous water, and with a long soft brush dust some French chalk over the surface.

Now place the flong on the face of the type, the tissue downwards. Cover it with a damp linen cloth, and with the hard brush commence to beat, beginning at one end of the forme and advancing to the other, in order to exclude the air from the surface of the type. If this be not attended to, it is probable that an imperfect mould will be the result. If the work be very open, or composed of rule-work, the blank parts may be pricked with a pin to liberate the confined air.

Beating the flong is undoubtedly the most difficult process to be mastered, and it is only with great care and judgment that a really good mould can be obtained. The handle of the brush must be held in such a manner as to enable the bristles to fall positively flat on the back of the flong: if it falls unevenly, the mould will be distorted, and perfectly useless, besides which, the face of the type will be injured. The process requires much practice to perform it successfully.

In time, the bristles of the brush become somewhat rounded, especially with careless beating, in which case difficulty will be experienced in obtaining a sharp and perfect matrix; besides this, the flong will require more beating, and the type will be rapidly worn down. As soon as the brush shows signs of wear, rub it carefully, while in a perfectly horizontal position, on the hottest part of the oven floor, so that any protruding hairs may be charred till they assume the level of the majority. This is sometimes done even with new brushes.

When the impression of the types is plainly seen at the back of the flong, paste a piece of thick wrapper paper on the top, and beat again; after this, lay on another piece, and proceed as before. The mould may now be of sufficient thickness, and the operator can determine if such be the case by lifting one corner and examining the impression. If any portion appears to be deficient in sharpness or depth, paste another piece on and carefully beat again in the shallow part. The whole of the flong should never be lifted off the type until it is determined that the mould is satisfactory, as great difficulty may be experienced in replacing it. If there are any "whites" in the mould, cut a piece of an old mould half the size of the open space, and paste on. This will prevent the metal from being too high in the plates, and obviate chipping. When the mould is of sufficient and uniform depth all over, softly plane the back. After having tightened the quoins, proceed to the drying process.

Drying the Flong.—The melting pot and furnace have already been described. The flue of the furnace is conducted through the drying plate, on

which the moulds are baked and dried. This is a long, thick iron slab, made hollow, to admit of the smoke passing from the furnace to the chimney. At one point is fixed a press for drying the moulds, the platen of which is adjusted by a strong, upright screw, having a wheel at the top. The use of dry heat for baking the mould is sometimes liable to destroy the type by rounding the bottom. A steam-chest is preferable, the entry and escape of the steam being regulated by screw-valves placed under the table.

The iron imposing surface for laying up, re-imposing the page, and making the mould has already been mentioned. A second surface should be provided, at a slightly lower level. Type-high clumps and chases are placed round the pages previous to moulding.

Drying the Mould.—Proceed to lift the forme and place it on the drying surface under the press, taking care that the mould does not become misplaced during the operation. Cover the back with 2 or 3 pieces of blanket, and tightly screw down the platen, if the page be solid, but use less pressure in the case of an open or title-page. Some 10–15 minutes are required for the drying operation, after which it is well to loosen the platen, so as to relieve the forme of pressure for a minute or two, to allow steam to escape. Owing to the great heat, the quoins may possibly have become loose; it is advisable to tighten them before removing the forme to the imposing surface. The mould will now adhere somewhat tightly to the type; its removal must be patiently effected, or it will surely be spoilt. Carefully raise one corner at a time with the forefinger and thumb, lifting it higher each time, when the mould will leave the type. Should it, from any cause, such as imperfect oiling, adhere so firmly as to resist the ordinary means of lifting, the beating brush may be applied to the back. If this fails, the mould will have to be destroyed by pouring cold water on the back after the forme has been again heated.

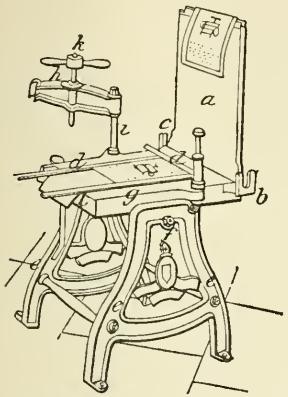
According to Byles' method, in use at the *Bradford Observer* office, the mould, instead of being dried upon the forme from which it is taken, is lifted off in a moist state, placed in a special frame, and subjected to the necessary amount of heat. The inventors claim for this process several advantages, the most important of which is, perhaps, the prevention of injury to the type; type suffers considerably from being repeatedly subjected, under pressure, to great heat, the bottom becoming rounded. A saving is also effected in the original cost of the plant, no drying process or surface being required. Fuel is saved only when the drying surface is heated independently. On the other hand, a new item of cost arises in the purchase of the drying frame. A saving of time, however, is undoubtedly effected by the adoption of this process, as the mould can be properly baked in 3–4 minutes, whereas nearly double this time is usually occupied in the operation. As the forme is not heated, the type is ready for distribution immediately the mould is lifted, certainly an additional advantage.

Baking the Mould.—Before commencing to bake the mould, trim it with a pair of shears to the proper size, allowing sufficient margin to admit of the gauges lying securely on the surface. Cut a piece of brown paper the same width as the mould, and 6–8 in. long, and paste on the top edge of the page. This is to lap over the mouth of the casting box, and prevent the molten metal from running to the back of the mould when the plate is being cast. Lay the matrix on its back on the heating surface to bake. To keep it perfectly flat, and prevent its warping, place weights on the sides: type-high clumps are admirably suited for this purpose. After about 15–20 minutes, it will be perfectly dry and hard, and ready for use. Previous to placing it in the casting box, put a little French chalk over the surface with a long-haired soft brush.

Casting the Plate.—The casting box, Fig. 180, consists of 2 thick iron sur-

faces, the top one *a* serving as a lid. The hinges *b* are made by 2 protruding pins at one end, fitting loosely into slots *c* on either side of the bed. By this means, plates of any thickness can

FIG. 180.



be cast, the height being regulated by the steel gauges *d* placed round the mould. The box is supported in a low upright frame *e* by 2 swivels *f* in the centre. The lid *a* and bed *g* are held firmly together by a movable bar *h*, which works loosely on a pin *i* on one side of the bed, and when the lid is closed down, may be swung round and securely clamped by a centre screw *k*. The mouth *l* of the box is slightly bevelled inwards, to admit of the metal being poured without spilling. The casting box being nicely balanced in its frame, but little power is needed in the tilting for pouring, &c. When it is moved either in an upright or horizontal position, it is secured by self-acting springs. The steel gauges *d* are usually 1 pica thick.

To prevent the metal being too rapidly chilled while it is being poured, it is necessary to heat the casting box prior to placing the mould, usually done by pouring a ladleful of molten metal into the box, and letting it remain for a minute or two, when the box can be opened and the block removed. When first commencing work, this should be done 2 or 3 times. After carefully wiping clean the surface of the box, place the mould in the centre, face upward, and allow the brown paper that has been previously fastened to the top of the page to lap over the front of the mouth of the casting box, to ensure the metal running directly to the face of the mould. The gauges are now put round the mould. The lid of the box is next closed, clamped, and secured by the upright screw. The side spring is disengaged, and the box swung into a vertical position, when the mouth will be at the top. If the brown paper before-mentioned is liable to obstruct the flow of the metal, place a small wooden wedge at either corner.

With the skimmer again carefully remove any dross that may have accumulated on the surface of the metal. Ascertain that it is of the proper temperature, as already directed, and take sufficient in the ladle for the whole casting. This is in all cases necessary, as the metal, immediately it comes into contact with the casting box, solidifies, and the addition of a second lot would assuredly spoil the appearance of the plate, as it would be imperfect at the junction. When large castings are made, the ladle is sufficiently capacious to hold the requisite quantity of metal, having a handle at each end to admit of 2 workmen lifting it. As the large ladle cannot conveniently be dipped into the metal, it is filled by a smaller ladle, but prior to this it should be heated by being first filled with hot metal, which can be emptied back again. The casting box must be perfectly dry before pouring.

The metal should be slowly run into the mouth of the casting box, without splashing. Sufficient being poured in, it is allowed to remain for 2–3 minutes, by which time it will have set. The box is then swung into a horizontal position, the clamp is unfastened, the lid lifted, and the plate will be found lying on its face. The gauges are re-

moved, and the casting is laid on the imposing surface, the workman wearing a long leather apron and being provided with thick blanket-pads for handling the still hot plate and box.

Trimming the Plate.—When the casting is sufficiently cool, the superfluous metal at the head, called the "tang," or "pour-piece," is removed by a circular saw or sharp-pointed hook. If more than one page has been cast, the pages must be separated in the same way, and trimmed to a gauge. The newly-cast plate is slightly thicker than is required, and is also uneven on the back, in consequence of the unequal contraction of the metal. It is next subjected to the planing and bevelling processes already described for plaster-cast plates. The circular saw should have a screen of sheet tin or iron, or thick glass, to protect the workman from the flying scraps of metal.

Supplementary Remarks.—Small complete stereotype-foundries are fitted up for heating by gas, by Harrild's and other firms, at prices ranging from about 20 guineas upwards.

For newspapers, the plates are often made type-high, but with an iron core introduced beneath, to reduce the consumption of metal, which core will need heating the same as the mould before casting. Several ingenious contrivances are in the market for casting solid plates of any size without the necessity of having special cores.

BOOKBINDING.—By "binding" a book is meant the arrangement of the "sheets" composing it, with maps, plates, &c., in proper sequence, within a pair of covers, of various material, with or without ornamentation, and in such a manner that the pages can be turned over separately without being detached. The art is divided into a number of operations.

Folding.—The first step is to fold the printed sheets evenly, by laying them on a table with the "signatures" (figures or letters on the first page of each sheet) at the left side facing downwards. The sheet is folded over from right to left, carefully placing the "folios" (numbers of the pages) together, and held so while the folding-stick, carried in the right hand, is drawn across the sheet, creasing the centre. Next the folder is held where the new crease is to be made, and the top half is folded downwards in the same even manner. This order is repeated till the sheet assumes the form of a page.

Books that have already been folded, and issued in numbers, must be "pulled to pieces" or divided before binding. The parts being arranged in order, the outside wrappers are torn away, and each sheet is pulled out singly, cutting any thread used in sewing the centre of the sheet at the back. Even if the sheets have not been properly done in the first instance, refolding is not often resorted to, the previous creasing rendering the paper liable to be torn; books that have been bound and cut would be rendered worse by refolding. The "groove" is knocked down on a flat surface, after screwing it up in the laying press (the groove is the projection of the book at right angles to the back, and is where the back edge of the board or cover hinges). The edge of each sheet (from a folded work) being cleared of all adhering glue, &c., the book is ready for the next process. In large establishments folding is done by machine. A very useful auxiliary to hand folding is a revolving table carrying the sheets in succession before the gatherers.

Beating and Rolling.—The object of these processes is to make the book solid. Use is made of a stone or iron slab, perfectly smooth, and bedded with great solidity; and a bell-shaped hammer, weighing about 10 lb., with a short handle fitting the hand. The faces of both hammer and "stone" must be kept clean, and it is well to lay a piece of paper above and below the "sections" when beating, or the repeated concussion will glaze them. Each "section" or lot should be about $\frac{1}{4}$ in. thick, that will be 15–20 sheets, according to the thickness of paper. The section is held between the fingers and thumb of the

left hand, resting on the stone; the hammer, grasped firmly in the right hand, is raised, and brought down with rather more than its own weight on the section, which is continually moved round, turned over and changed about, in order that it may be equally beaten all over. By passing between the fingers and thumb, it can be felt whether it has been properly and evenly beaten. In each blow of the hammer, the face must fall fairly on the body of the section; if the hammer is used so that the greatest weight falls outside the edge of the sheets, the paper will break away as if cut. After each section has been beaten, the whole are put together and beaten again.

Rolling sometimes replaces beating. But all books should not be rolled, and it is essential to know how and when to use the beating hammer, and when the rolling machine. Old books should on no account be rolled. The early printing presses exerted such pressure on the type that the paper round the margins is often 2 or 3 times as thick as the printed portion. For modern work, the rolling machine is, as a rule, better than the hammer.

For rolling, the book is also divided into sections, but fewer sheets are taken —from 6 upwards, according to the quality of the work. The sheets are placed between tins, and the whole passed under a roller, which is adjusted to the thickness of the sections and the power required, by a screw provided for the purpose. Some binders execute rolling at a small charge for others.

Collating.—Each sheet or leaf must be put in its proper sequence, according to the "signatures." Plates are trimmed or cut to the proper size before being placed in the book; and maps that are to be folded must be put on "guards." A map mounted on a guard of the size of the page may be kept laid open on the table beside the book, which can be read at any part without concealing the map; this is called "throwing out" a map.

For collating, the book is held in the right hand, at the right top corner, a turn of the wrist bringing the back to the front. The sections are fanned out, and with the left hand brought back to an angle, which will cause them when released to spring forward, so that the letter on the right bottom corner of each sheet is seen and released in succession. The book must always be beaten or rolled before placing plates or maps, especially if coloured.

After ascertaining that the letterpress is perfect, the plates are collated and squared with a sharp knife and straight-edge. If printed on paper larger than the book, the plates must be cut down to the book size, leaving less margin at the back than there will be at the foredge when the book is cut. Frontispiece plates face to the left; but as a general rule, plates should be placed on the right hand, so that on opening the book they face upwards. With plates at a right angle to the text, the inscriptions are placed on the right margin, whether the plate faces to the right or left. Plates on thick paper must be "guarded," either by adding a piece of paper of the same thickness, or by cutting a piece off the plate and rejoining with a strip of linen, so that the plate works on a linen hinge. The width between the guard and the plate must equal the thickness of the paper. Cardboard plates are strengthened by putting linen at both back and front. If a book consist of plates only, sections may be made by placing 2 plates and 2 guards together, and sewing through the centre between the guards, leaving a space between the guards to form the back.

Maps are best mounted on the finest linen (which takes up the least room in thickness), cut a little larger than the map, with an additional piece left, on which to mount the extra paper, which throws the map out. The latter is trimmed at its back first, then brushed with rather thin paste; the pasting-board being removed, the linen is laid on, gently rubbed down, and turned over, so that the map comes to the top; the white paper is then placed a little away from the map, and the whole is well

rubbed down, and finally laid out flat to dry. The paste must be clean, free from lumps, and used very evenly and moderately. The map, when dry, is trimmed all round, and folded to its proper size—a little smaller than the book will be when cut.

With all folded maps or plates, a corresponding thickness must be placed in the backs where the maps go, or the foredge will be thicker than the back. Pieces of paper called guards, folded ¼–1 in. in width, according to the size of the book, and placed in the back, are sewn through as a section; but care must be taken that the guards are not folded so large as to overlap the folds of the map, or the object of their being placed there will be defeated. It is easy to ensure the pasting being straight along the edge of a paper plate by placing a strip of waste paper to mark the limit and receive the spreading of the brush.

Having placed the plates, go through them again when dry, see that they adhere properly, and break or fold them over up to the pasting, with a folding-stick, so that they will lie flat when the book is open. Coloured plates should be looked after during the whole of binding, especially after pressing. The gum on their surfaces may cause them to stick to the letter-press; in this case do not try to tear them apart, but warm a polishing iron, and pass it over the plate and letter-press, laying a piece of paper between the iron and the book to avoid dirt. The heat and moisture will soften the gum, and the surfaces can then be very easily separated. Rubbing a little powdered French chalk over the coloured plates before sticking them in, acts as a preventive.

If a book is entirely composed of single leaves, it should be collated properly and the plates placed in their places, squared and broken over, by laying a straight-edge about ½ in. from the back edge, and running a folder under each plate, thus lifting it to the edge of the runner. The whole book is then pressed for a few hours and taken out; the back, previously roughed with the side edge of a saw, is glued up, thus. The book is put into the laying press between boards, with the back projecting about ⅛ in.; the side edge of the saw is then drawn over it, so that the paper is rasped; the back is then sawn in properly, as explained in the next section, and the whole back is glued. After drying, the book is separated into "sections" of 4, 6, or 8 leaves, according to the thickness of the paper, and each section is then "overcast" or "over sewn" along its whole length. The thread being fastened at the head and tail (top and bottom), each section is made independent of the others. The sections are then (2 or 3 at a time) gently struck along the back edge with a hammer against a knocking-down iron, to imbed the thread in the paper, or the back would be too thick. Having placed the plates, the book is put into the press for a few hours, when it will be ready for "marking up" if for flexible sewing, or for "sawing in," if for ordinary work. The presses used by bookbinders are called "standing" and "laying," the latter name being obviously a corruption of "lying."

For interleaving writing paper between the leaves of letter-press, the book must be properly beaten or rolled, and each leaf cut up with a hand-knife, both at the head and foredge; the writing paper is then folded to the size of the book and pressed. A single leaf of writing paper is fastened in the centre of each section, and a folded leaf is placed to every folded letter-press leaf, by inserting the one within the other, leaving to every other section a folded writing paper outside, putting them all level with the head; the whole book is finally well pressed.

FIG. 181.

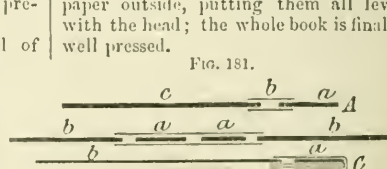


Fig. 181 illustrates methods of inserting guards: in A, *a* is the guard, *b* the linen hinge, and *c* the plate; in B, *a* are

the guards, covered on each side with linen, and *b* are the plates, the dot between the guards indicating where the sewing through takes place; in C, which is B closed, are the linen-covered guards, and *b* the plates.

Marking up and Sawing in.—After having been for a night in the press, the book is again collated, knocked straight at both head and back, and put into the laying press between boards, projecting beyond them about $\frac{1}{8}$ in. The boards are held between the fingers of each hand, and the back and head are knocked alternately on the cheek of the press; the boards being then withdrawn the required distance from the back of the book, the book and boards are held tightly with the left hand, and the whole carefully lowered into the press, the right hand being employed to screw up tightly, holding the book quite straight, and firmly.

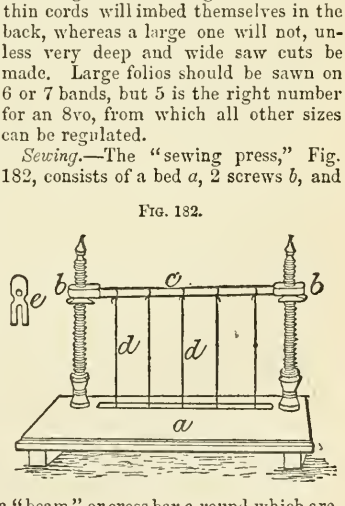
If the book is to have "flexible" binding, it is not sawn in, but marked, the difference being that the cord is outside the sheets, instead of being imbedded in the back in a groove made by the saw.

For the flexible binding of an ordinary 8vo volume, to be cut all round, the back is divided into 6 equal portions, leaving the bottom or "tail" $\frac{1}{2}$ in. longer than the rest, to accommodate an optical illusion, by which, if the spaces were all equal, the bottom one would appear to be the smallest. The marks on the back are exactly squared, and marked pretty black with a lead pencil. The head and tail are next sawn in to imbed the chain of the kettle-stitch, at a sufficient distance to prevent the thread being accidentally divided in cutting. Great accuracy is absolutely necessary in flexible work, especially in the marking up, as the bands on which the book is sewn remain visible after covering. A very small book, such as a prayer-book, is marked up for 5 bands, but only sewed on 3, the other 2 being fastened on as false bands when the book is ready for covering.

A book that is to be "sawn in" is marked up as for flexible work, but the back is sawn, both for the bands and "kettle-stitch," with a tenon saw, having the teeth not spread out too much, and of suitable width of cutting face. The cut must not enter too deeply, and must in all cases be guided by the thickness of cord to be used. The size of the book determines the thickness of the cord; suitable kinds can be purchased, being known by the size of the book, as 8vo, 4to, &c. Loose cording causes great inconvenience, and necessitates putting a lot of glue into the grooves to keep the cord in place. On the other hand, if the saw-cuts are not deep enough, the cord will stand out from the back, and be seen when the book is finished, if not remedied by extra pieces of paper between the bands when lining up. Double thin cord is better than single thick for large books, because thin cords will imbed themselves in the back, whereas a large one will not, unless very deep and wide saw cuts be made. Large folios should be sawn on 6 or 7 bands, but 5 is the right number for an 8vo, from which all other sizes can be regulated.

Sewing.—The "sewing press," Fig. 182, consists of a bed *a*, 2 screws *b*, and

FIG. 182.

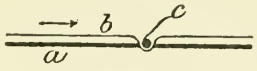


a "beam" or cross bar *c*, round which are fastened 5 or more "lay cords" *d*; 5 pieces of cord cut from the ball, in length measuring about 4 times the thickness of the book, are fastened to the lay cords by slip knots, the other ends being fastened to small pieces of metal called "keys" *e*, by twisting the ends round twice and then making a "half hitch."

The keys are passed through the slot *f* in the bed of the "press," and the beam is screwed up loose enough to allow the lay cords to move freely backwards or forwards. The book being on the bed of the press, with the back towards the sewer, a few sheets are laid against the cords, and exactly to the marks made on the back of the sections; when quite true and perpendicular, they are tightened by screwing the beam up. If the cords are a little to the right, the sewer can get his left arm to rest better on the press.

Fig. 183 represents the course of the thread in sewing the sheet to the bands;

FIG. 183.



a being the back of the book, *b* the thread, and *c* the cord, an arrow indicating the direction of the thread.

The first and last sections are strengthened by overcasting with cotton. The first sheet is laid against the bands, and the needle is introduced through the kettle-stitch hole on the right (head) of the book; the left hand being inside the centre of the sheet, the needle is taken with it, and thrust out on the left of the mark made for the first band; the needle is taken in the right hand, and again introduced on the right of the same band, thus making a complete circle round the band. This is repeated with each succeeding band, and the needle is finally brought out of the kettle-stitch hole on the left (tail) of the sheet. Another sheet is placed on the top, and similarly treated, by introducing the needle at the left end (tail); and when taken out at the right end (top), the thread is fastened by a knot to the end, hanging from the first sheet, which is left long enough for that purpose. As a thread is used out, another is joined to it, making it continuous; the knots must be made very neatly, and the ends cut off. A third sheet having been sewn like the others, the needle is brought out at the kettle-stitch, thrust between the two sheets first sewn, and drawn round the thread, thus securing each sheet to its neighbour by a kind of chain stitch. This is the strongest way of sewing, and takes 3 or 4 times as long as ordinary sewing. The thread must be drawn tight each time it passes round the band, and finally properly fastened off at the kettle-stitch, or the sections will work loose in time. The cord for flexible work is called "flexible"; it is twisted tighter and is stronger than any other, Marshall's being the best. The thickness of the cord must be proportioned to the size and thickness of the book, and will partly depend on whether the sheets are halves or wholes. Too thick a thread will make the "swelling" (the rising caused in the back by the thread) too much, and prevent a proper rounding and a right sized "groove" in backing. With thick or few sections, a thick thread must be used to produce a good groove.

In a book of moderate thickness, the sections may be knocked down by occasionally tapping them with a piece of wood loaded at one end with lead, or with a thick folding-stick. In the kettle-stitch, the thread must not be drawn too tight in making the chain, or the thread will break in backing; nor left too slack, or the sheets will wear loose. The last sheet should be fastened with a double knot round the kettle-stitch, 2 or 3 sections down, and that section must be sewn all along.

Ordinary sewing differs in that the thread is not twisted round the cord. The cord fits into the saw cuts; the thread is passed over the cord, not round it, and then along the section, out of the holes made, and into them again, the kettle-stitch being made in the same way. In this style, the back of the book can be better gilt: in flexible work, the leather is pasted to the back, and is bent each time the book is opened, incurring a risk of the gold breaking away from the leather in wear. Books sewn in the ordinary method are made with a hollow back, and when the book is opened, the crease in the back is in-

dependent of the leather covering, so that the lining of the back only is creased, and the leather keeps its form because the lining gives it a spring outwards. Morocco leather is always used for flexible work. Ordinary sewing is adapted for books that do not require great strength, such as library bindings; but a book for constant reference or daily use should be sewn flexibly.

In the method called "flexible not to show," the book is marked up in the same way as for flexible, and is slightly scratched on the band marks with the saw, but not deep enough to go through the sections. Then a thin cord is doubled for each band, and the book is sewn in the ordinary flexible way. The cord is knocked into the back in forwarding, and the leather may be stuck on a hollow back with bands, or to the back itself without bands.

In order to keep down the swelling of the book to the proper amount necessary to form a good backing groove and no more, the sheets must from time to time be gently tapped down with a heavy folding-stick, and great care must be observed to avoid drawing the fastening of the kettle-stitch too tight, or the "head" and "tail" of the book will be thinner than the middle,—a fault which, once committed, has no remedy.

Very thin sections, or half sheets, if the book is very thick, may be sewn "2 sheets on," i. e. the needle is passed from the kettle-stitch to the first band of the first sheet and out, then another sheet is placed on the top, and the needle is inserted at No. 1 band and brought out at No. 2; the needle is again inserted in the first sheet and in at No. 2 band and out at No. 3, thus treating the two sections as one, in which way, obviously only half as much thread will be in the back. With books that have had the heads cut, it is necessary to open each sheet carefully up to the back before it is placed on the press, otherwise the centre may not be caught, and 2 or more leaves will fall out after the book is bound.

Books composed of single leaves are overcast, and each section is treated as a section of an ordinary book, the only difference being that a strong paper lining should be given to the back before covering, so that it cannot "throw up."

Forwarding.—For "end" papers, the coloured paper is pasted on white, the style of binding deciding the choice. The usual kinds are as follows.

"Cobb" paper (used generally for half-calf bindings with sprinkled edge, or half-calf gilt top) is stained various shades and colours in the making, brown being the colour most favoured.

"Surface" paper has one side prepared with a layer of colour, laid on with a brush very evenly; some kinds are left dull, others are glazed. Darker colours are generally chosen for religious books, and lighter for cloth or case work. Many other kinds are put into "extra" bindings with good effect, e. g. a cream of fine colour and good quality in a morocco with cloth or morocco joints.

"Marbled" paper has colours disposed on it in imitation of marble, produced by sprinkling prepared colours upon a coating of size made from an emulsion or resinous solution.

"Printed" and "fancy" papers may be bought in any variety. "Coloured paste" paper may be home-made. Some colour is mixed with paste and soap till it is a little thicker than cream, then spread upon 2 sheets of paper with a paste brush; the sheets are next laid with their coloured surfaces in contact, and when separated will bear a wavy pattern. The paper is hung up till dry, and glazed with a hot iron.

Having decided upon the kind of paper to use, cut and fold 2 pieces to the size of the book, or a trifle larger, especially if the book has been already cut; also prepare 2 pieces of white paper in the same way. This done, a white paper is laid down, folded, and very evenly brushed with moderately thin paste; the 2 fancy papers are laid on the top, level with the back or folded edge; the top fancy paper is pasted, and the other white is laid on that; next take them from the board, and after a squeeze in the press, hang them

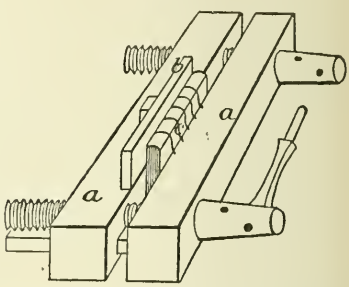
up separately to dry. Thus one half of the white will adhere to one half of the marbled or fancy paper. When dry, they are folded in the old folds, and pressed for ¼ hour. As many as 10–15 pairs may be done at once, by commencing with 1 white, then 2 fancy, 2 white, and so on, always pressing, to ensure the surfaces adhering properly, then hanging up to dry, and, when dry, pressing again, to make them quite flat.

In pasting, be sure to draw the brush well over the paper and away from the centre, towards the edges of the paper. Take just enough paste on the brush to make it slide well. See that the whole surface is pasted; remove all hairs and lumps from the paper, or they will mark the book; and never attempt to take up the brush from the paper before it is well drawn over the edge, or the paper will stick to the brush and turn over, with the risk of pasting the under side.

Pasting up.—In every book, the first and last sheet must be "pasted up"; and if the book has too much "swelling," it must be tapped down gently with a hammer, holding the book tightly at the foredge with the left hand, knuckles down, and resting the back on the press. A better plan is for the back to be knocked flat on the laying press, placed in it without boards, so that the back projects, screwed up tightly, so that the sheets cannot slip; a knocking-down iron is then placed against left side of the book, and the back is hammered against it. The "slips" or cords are pulled tight, each with the right hand, the left hand holding them against the book so that they shall not be drawn through. The process is illustrated in Fig. 184: *a*, press; *b*, knocking-down iron; *c*, book. If a slip is accidentally pulled out, it is necessary to re-sew the book.

When the slips have been pulled tight, the first and last section are pasted to those next them, thus:—Lay the book on the edge of the press, throw the top section back, lay a piece of waste paper upon the next section ⅛–¼ in. from the back, according to the size of the book, and paste the space between the back and the waste paper, using the second finger of right hand, and holding the paper down with the left. After pasting, the waste paper is removed,

FIG. 184.



and the section is put even with the back of the book, which is turned over so that it may not shift, and the other end is treated in the same manner. Finally a weight is put on the top, or if a number of books, one may lie on the top of the other, back and foredge alternately, each ½ in. within the foredge of the next, with a few pressing boards on the top. After drying, the end papers are put on.

Pasting on the End Papers.—For each side of the book, a single leaf of white paper, somewhat thicker than that used for the ends, is cut. Lay the end papers on a board or on the press, with the pasted side uppermost, and put the single leaves on the top. Fan them out evenly to a proper width (about ¼ in. for an 8vo), lay a piece of waste paper on the top, and paste their edges. Having thrown the slips back, the white flyleaf is put on the book, a little away from the back, the made ends on the top are placed even with the back, and the book is again left to dry beneath a weight.

Very heavy or large books should have bookbinders' cloth or leather "joints" matching the colour of the cover, morocco being mostly used for leather joints. Cloth joints may be added either when the ends are being put on, or when

the book is ready for pasting down. Now the cloth is cut 1–3 in., according to the size of book, and folded quite evenly, leaving the side of the cloth to go on the book the width intended to be glued: thus a width of 1 in. should be folded $\frac{3}{4}$ on one side, leaving $\frac{1}{4}$ on the other, and putting the $\frac{1}{4}$ on the book. Having glued the smallest fold, the white fly-leaf is put on, and the fancy paper on the top. The difference here is that the paper is single, or is cut to the size of the book and pasted all over. It is best to paste the marble paper, put on the white, rub well down, and lay them between millboards to dry. Finally a piece of waste or brown paper may be slightly fastened at the back over the whole, turning the cloth down on the book to keep it clean and prevent injury.

When the cloth joint is to be put on after the book is covered, the flyleaves and ends are only edge-pasted to the book just to hold them while it is being bound; when the book is to be pasted down, the ends are lifted from it by running a thin folding-stick between the ends and the book. The cloth is cut and folded as before, fastened on, and the ends and flyleaves are properly pasted in the back. Morocco joints are always put in after the book is covered.

Cloth joints go in better at the same time as the ends, taking care that the ends are quite dry after being made before attaching them, or their dampness will cause wrinkles.

The ends being quite dry, the slips are unravelled and scraped with a bodkin and a knife-back, so that they may with greater ease be passed through the holes in the millboard, and the cord be more evenly distributed and beaten down, to prevent their being seen in the covered book.

Trimming.—If the book is to be uncut, or to have a gilt top, the rough edges are "trimmed" off with a very sharp knife or shears. The book is knocked up straight, laid on a smooth-planed "trimming board," and compassed from the back as a guide; a straight-edge is laid on the compass holes, and the fore-edge is cut. The object being merely to make the edges true, only the rough and dirty edges are taken off, leaving the book as large as possible. Sometimes the book is put into the cutting press, and the overplus is taken off with a "round plough," especially if a number of books are to be done together. It is better to use the straight-edge and knife for the foredge and tail, and to cut the top when the boards are on the book.

Glueing up.—Glue is now applied to the back to hold the sections together, and make the back firm during the rounding and backing. Knock the book perfectly true at its back and head, and put it into the laying press between 2 pieces of old millboard; expose the back, and let it project from the boards a little, the object being to hold the book firm and to keep the slips close to the sides, so that no glue shall get on them; then with glue, not too thick, but hot, glue the back, rubbing it in, and taking the overplus off again with the brush.

A handful of shavings is sometimes used to rub the glue in, and take the refuse away, but a great quantity of glue is thus wasted. The Germans rub the glue in with the back of a hammer, and take away the overplus with the brush; this is better than using shavings. The back must not be allowed to get too dry, before it is rounded, or it will have to be damped with a sponge, to give the glue the elasticity required, but being wet is worse than letting it get too dry. The book should be left for about an hour, or till it no longer feels tacky to the touch, but still retains its flexibility. A flexible bound book should be rounded first, using a backing board to bring the sheets round, instead of a hammer; then the back is glued, and a piece of tape is tied round the book to prevent its going back flat.

All books are not glued up in the press; some workmen knock up a number of books, and, allowing them to project a little over their press, glue the lot up at once; others, again, hold the book in the left hand, and draw the brush up and down the back. These last methods

are, however, only practised in "cloth shops," where books are bound or cased at very low prices. The proper way is to put the book in the press; and if more than one, they should be laid alternately back and foredge, with the back projecting about ½ in., and allowed to dry spontaneously, on no account being dried by the heat of a fire, as all artificial heat in drying in any process of bookbinding is injurious to the work.

Rounding.—"Rounding" applies to the back of the book, and is preliminary to backing. In rounding the back, the book is laid on the press before the workman with the foredge towards him, and held with the left hand by placing the thumb on the foredge and fingers on the top of the book pointing towards the back, so that by drawing the fingers towards the thumb, or by pressing fingers and thumb together, the back is drawn towards the workman at an angle. The back is then struck gently with the flat or face of the hammer, beginning in the centre of the back, still drawing the back over with the left hand. The book is then turned over, the other side is treated in the same way, and so continually changed or turned until it has its proper form, which should be about ⅓ of a circle. When sufficiently rounded, it is examined to see if one side be perfectly level with the other, by holding the book up and glancing down its back, and gently tapping the places where uneven, until it is perfectly uniform. The thicker the book, the more difficult to round it; and some papers will be found more obstinate than others, so that great care must be exercised both in rounding and backing, as the foredge when cut will have exactly the same form as the back.

Backing.—"Backing-boards" should be of the same length as the book, somewhat thicker than cutting-boards, and with their tops planed at an angle, so that the sheets may fall well over.

Hold the book in the left hand, lay a board on one side, a little away from the back, taking the edge of the top sheet as a guide, the distance to be a trifle more than the thickness of the boards to be used. The book, with the backing-board, is then turned over, holding the boards to the book by the thumb, so that it does not shift; next lay the other board at exactly the same distance on the other side. The whole is now held tightly by the left hand, and lowered into the press. The boards may possibly have shifted a little during the process, and any correction may now be made whilst the press holds the book before screwing up tight, such as a slight tap with the hammer to one end of a board that may not be quite straight. Should the boards however be not quite true, it will be better to take the whole out and readjust them, rather than lose time in trying to rectify the irregularity by any other method.

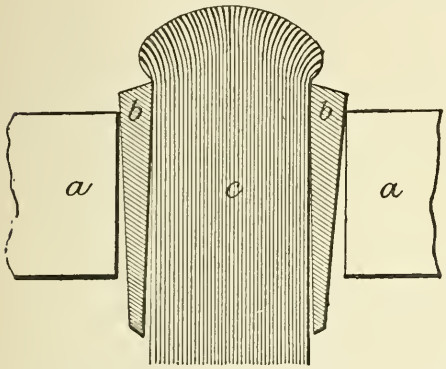
The book and boards being lowered flush with the cheeks of the press, screw it up as tightly as possible with the iron hand-pin. The back of the book must now be gently struck with the back of the hammer, holding it slanting, and beating the sheets well over towards the backing-boards. Commence from the centre of the back and do not hit too hard, or the dent made by the hammer will show after the book has been covered. The back is finished with the face of the hammer, bringing the sheets well over on the boards so that a good and solid groove may be made. Each side is to be treated in the same way, and have the same amount of weight and beating. The back must receive a gradual hammering, and the sheets, when knocked one way, must not be knocked back again. The hammer should be swung with a circular motion, always away from the centre of the back. The book, when opened after backing, should be entirely without wrinkles. Backing and cutting constitute the chief work in forwarding, and if these are not done properly, the book cannot be square and solid—great essentials in bookbinding.

Backing flexible work is a little more difficult, as the slips are tighter; otherwise the process is exactly the same, only care must be taken not to hammer the cord too much, and to bring over

the sections very gently, in order not to break the sewing thread.

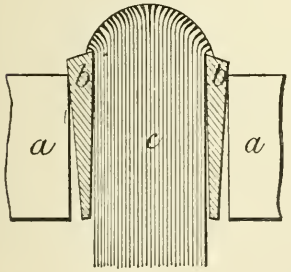
Fig. 185 illustrates a section of a book in the press before backing: *a*, press;

FIG. 185.



b, backing-boards; *c*, book. Fig. 186 represents a section of the same book in the press after backing.

FIG. 186.



Millboards. — The workman should take advantage of the period of drying to select the proper thickness of boards, and line them with paper on one side or both.

First square the edge which is to go to the back of the book, in the cutting-press, using a cutting-board for one side termed a "runner," and another called a "cut-against" for the other side. These are to save the press from being cut; and a piece of old millboard is generally placed on the cut-against, so that the plough-knife does not cut up the latter too quickly. The boards, if for whole-binding, are lined on both sides with paper; if for half-binding, on one side. The reason for lining is to make the boards curve inwards towards the book. The various pastings would cause the board to curve the contrary way if it were not lined. It may be taken as a general rule that a thinner board when pasted will always draw a thicker one. If the boards are lined on both sides, paper is cut double the size of the boards; if on one side, the paper is cut a little wider than the boards, so that a portion of it may be turned over on to the other side about $\frac{1}{4}$ in. The paper is brushed with not too thick paste, and the board is laid on the paper with the cut edge towards the portion to be turned over. It is now taken up with the paper adhering, laid on the press with the paper side upwards, and rubbed well down; again turned over, and the paper drawn over the other side. Press the boards so as to be quite sure that the paper adheres.

When books are very thick, 2 boards may be stuck together, not only to get the proper thickness, but for strength. If a board has to be made, a thick and a somewhat thinner board should be put together. Paste both boards, and put them in the standing press for the night. Great pressure should not be put on at first, but after allowing them to set for a few minutes, pull down the press as tight as possible. When putting made boards to the book, the thinner one should always be next the book.

When boards are lined on one side only, it is usual to turn $\frac{1}{2}$ in. of the paper over the square edge, and the lined side must be placed next the book.

There are many kinds of boards made.

Black boards made of old rope vary much in quality, but the blacker, harder, and smoother they are the better. The grey or white boards, used mostly for antique work, are pasted on a thin black board, and bevelled down to the black one to the required width and angle. The boards used extensively for cloth work are yellow and are made from straw, or from wood pulp. All boards are sold by weight, no matter what size or thickness.

The most useful implement for cutting the boards up are large shears, costing 16–30*s*. One arm or shank is screwed into the laying press, and the other, left free, is used with the right hand; the left hand holds the board to be cut.

Boards, when lined, are laid out to dry, and, when dry, cut to the size of the book. The requisite width is obtained by extending the compasses from the back of the book to the edge of the smaller bolt or fold in the foredge. After screwing them up, the boards are knocked up even, compassed up, and cut in the laying press, using as before, the "cut-against," and placing the runner exactly to the compass holes. When cut, they are tested by turning one round and putting them together again; if they are the least out of truth, it will be apparent at once. The "head" or top of the boards is next cut by placing a square against the back, and marking the head with a bodkin. The boards being quite straight are again put into the press and cut, and when taken out should be again proved by reversing them as before; if not true, they must be recut. The length is taken from the head of the book to the tail, and in this some judgment must be used. If the book has already been cut, the boards must be somewhat larger than the book, leaving only such an amount of paper to be removed as will make the edge smooth. If, however, the book is to be entirely uncut, the size of the book is taken, and the portions called "squares" that project round the book, in addition.

When a book has not been cut, the amount to be cut off the head will give the head or top square, and the book being measured from the head, another square or projection must be added to it, and the compass set to one of the shortest leaves in the book. Bearing in mind the section on trimming, enough of the book only should be cut to give the edge solidity for either gilding or marbling. A few leaves should always be left not cut with the plough, to show that the book has not been cut down. These few leaves are called "proof," and are always a mark of careful work.

Drawing-in and Pressing.—The boards having been squared, they are attached to the book by lacing the ends of the cord through holes in the board. The boards are laid on the book with their backs in the groove and level with the head; they are then marked with a pencil or bodkin exactly in a line with the slips, about ½ in. down the board. Holes are next made in the board with a short bodkin (with a piece of wood beneath) on the line, at a distance from the edge in accordance with the size of the book. About ¼ in. away from the back is the right distance for an octavo. The board is turned over, and a second hole is made about ½ in. away from the first ones. The boards having been holed, the slips are scraped, pasted slightly, and tapered or pointed. Draw them tightly through the hole first made, and back through the second. Tap them slightly when the board is down, to prevent them from slipping and getting loose. When the books are drawn-in, cut the ends of the slips close to the board with a knife, and well hammer them down on the knocking-down iron to make the board close on the slips and hold them tight. The slips should be well and carefully hammered, as any projection will be seen with great distinctness when the book is covered. The hammer must be held perfectly even, or the slips will be cut by the edge.

The book is now examined, and any little alteration may be made before putting it into the standing press. Pressing-boards, the same size as the book, should be put flush with the

groove, and in the centre of the press directly under the screw, which is tightened as much as possible. With all good books, a tin is put between the millboard and book, to flatten the slips and prevent their adherence to the book. The tin is put right up to the groove, and serves also as a guide for the pressing-board. In pressing books of various sizes, the largest is put at the bottom of the press, with a block or a few pressing-boards between the various sizes, in order to get equal pressure on the whole, and to allow the screw to come exactly on the centre of the books.

The backs of the books are pasted, and allowed to stand for a few minutes to soften the glue. Then with a piece of wood, called a "cleaning-off" stick, the glue is rubbed off, and the backs are well rubbed with a handful of shavings and left to dry. Let them lie as long as possible in the press, and, if the volume is rather thick, a coat of paste should be applied to the back.

In flexible work, care must be taken that the cleaning-off stick is not forced too hard against the bands, or the thread, being moist, will break; or the paper, being wet, will tear; or the bands may be shifted. The cleaning-off stick may be made of any piece of wood; an old octavo cutting-board is good.

When the volume has been pressed enough (at least 8 hours) it is taken out, and the tins and boards are put away. The book is then ready for "cutting."

Cutting.—All cutting "presses" are used in the same way: the plough runs over the press, and its left cheek runs between 2 guides fastened on the left cheek of the press. By turning the screw of the plough, the right cheek is advanced towards the left: the knife fixed on the right of the plough is advanced, and, with the point, cuts gradually through the boards or paper secured in the press, as already described in preparing the boards. There are 2 kinds of plough in use—in one the knife is bolted, in the other the knife slides in a dovetail groove—termed respectively "bolt knife" and "slide knife." The latter is preferable, on account of its facility of action, as any length of knife can be exposed for cutting. A bolt knife, being fixed to the shoe of the plough, is necessarily a fixture, and must be worn down by cutting or squaring millboards, or such work, before it can be used with the truth necessary for paper.

To cut a book properly, it must be quite straight, and the knife must be sharp and perfectly true. Having this in mind, the book may be cut by lowering the front board the requisite distance from the head that is to be cut off. A piece of thin millboard or "trindle" is put between the hind board and the book, so that the knife when through the book may not cut the board of the book. The book is now lowered into the cutting-press, with the back towards the workman, until the front board is exactly on a level with the press. The head of the book is now horizontal with the press, and the amount to be cut off is exposed above it. Both sides should be looked to, as the book is very liable to get a twist in being put in the press. When it is quite square, the press is screwed up tightly and evenly. Each end should be screwed up to exactly the same tightness; if one end is loose, the paper will be jagged or torn instead of being cut cleanly.

The book is cut by drawing the plough gently to and fro; each time it is brought towards the workman, a slight amount of turn is given to the screw of the plough. If too much turn is given to the screw, the knife will bite too deeply into the paper and will tear instead of cutting it. If the knife has not been properly sharpened, or has a burr upon its edge, it will be certain to cause ridges on the paper. The top edge being cut, the book is taken out of the press and the tail is cut. A mark is made on the top of the hind or back board just double the size of the square, and the board is lowered until the mark is on a level with the cut top. The book is again put into the press,

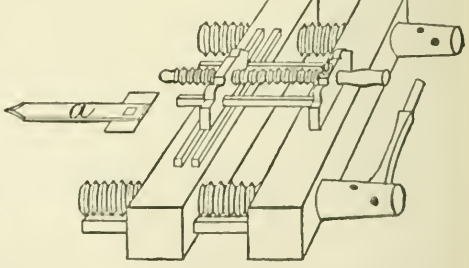
with the back towards the workman, until the board is flush with the cheek of the press; this will expose above the press the amount to be taken off from the tail, as before described, and the left-hand board will be, if put level with the cut top, exactly the same distance above the press as the right-hand board is below the cut top. The tail is cut in the same way as the top edge.

To cut a book properly requires great care. Always lay a book down one way and take it up another, and in cutting always work with the back of the book towards you, and cut from you. Give the turn to the screw of the plough as it is thrust from you, or you will pull away a part of the back instead of cutting it.

In cutting the foredge, always have the head of the book towards you, so that if not cut straight you know exactly where the fault lies. The foredge is marked at both back and front of the book by placing a cutting-board under the first 2 or 3 leaves as a support; the millboard is then pressed firmly into the groove, and a line is drawn or a hole is pierced at head and tail, using the foredge of the board as a guide. The book is now knocked with its back on the press quite flat, and "trindles" (flat pieces of steel in the shape of an elongated U, about 1½ in. wide and 3–4 in. long, with a slot nearly the whole length), are placed between the boards and book by letting the boards fall back from the book, and then passing one trindle at the head, the other at the tail, allowing the top and bottom slip to go in the grooves of the trindles. The object of this is to force the back up quite flat; by holding the book when the cut-against and runner are on it, supported by the other hand under the boards, it can be seen if the book is straight. The cut-against must be put quite flush with the holes on the left of the book, and the runner the distance under the holes that the amount of square is intended to be. The book being lowered into the press, the runner is put flush with the cheek of the press, and the cut-against just the same distance above the press as the runner is below the holes. The trindles are taken out from the book when the cutting-boards are in their proper place; the millboards will then fall down. The book and cutting-boards must be held very tightly, or the book will slip. If the book has been lowered into the press accurately, everything will be quite square. The press is screwed up tightly, and the foredge is ploughed; when the book is taken out of the press, it will resume its original rounding, the foredge will have the same curve as the back, and if cut truly there will be a proper square all round the edges. This method is known as "cutting in boards."

If the workman has a set of some good work which he wishes to bind uniformly, but which has already been cut to different sizes, and he does not wish to cut the large ones down to the smaller size, he must not draw the small ones in, as he may possibly not be able to pull his boards down the required depth to cut the book, so he must leave the boards loose, cut the head and tail, then draw the boards in, and turn up and cut the foredge.

FIG. 187.

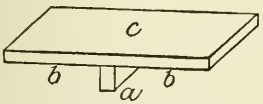


"Cutting out of boards" is by a different method. The foredge is cut before glueing up, taking the size from

the case, if for casing, from the back to the edge of the board in the foredge. The book is glued up, rounded, and put into the press for ½ hour, just to set it. The size is again taken from the case, allowing for squares at head and tail. The book, having been marked, is cut, and then backed. Cloth cases are made for most periodicals, and may be procured from their publishers at a trifling cost, which varies according to the size of the book and the amount of blocking that is upon them.

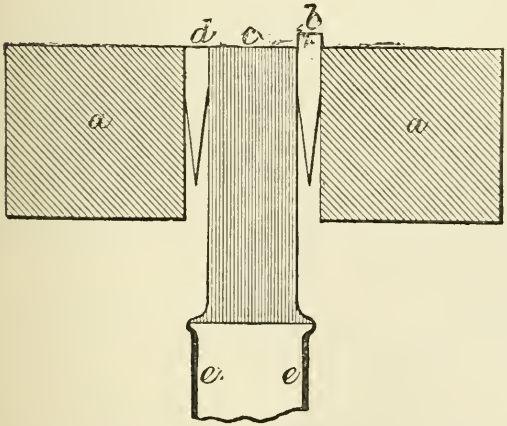
Fig. 187 illustrates the cutting-press, *a* being the knife. Fig. 188 shows the

FIG. 188.



knocking-down iron: the flange *a* is secured between the cheeks of the press; the sides *b* rest on the press; and the boards are hammered on the smooth face *c*. Fig. 189 is an ideal section of the cutting-press, representing the cut-

FIG. 189.



ting of a foredge of a book: *a*, jaws of press; *b*, cut-against; *c*, foredge of book; *d*, runner; *e*, boards of book.

Colouring the Edges.—The edges of a book should be in keeping with the binding. A half roan book should not have an expensive edge, nor a whole bound morocco book a sprinkled edge. Taste is the only guide.

Sprinkled Edges.—Most shops have a colour, usually a reddish-brown, which they use for all sprinkled edge books; it can be purchased at any oil shop. A mixture of burnt umber and red-ochre is generally used; the 2 powders are well mixed in a mortar with paste, a few drops of sweet oil, and water. The colour may be tested by sprinkling some on a piece of white paper, allowing to dry, and burnishing. If the colour powders or rubs, it is either too thick or has not enough paste in it. If the former, some water must be added; if the latter, more paste. It will be better if the whole is passed through a cloth to rid it of any coarse particles.

Books may be sprinkled so as to resemble a kind of marble by using 2 or 3 different colours. For instance, the book is put in the laying press and a little sand is strewn upon the edge in small mounds. Then with a green colour a moderate sprinkle is given. After allowing it to dry, more sand is put on in various places, a dark sprinkle of brown is put on, and the whole is allowed to dry. When the sand is shaken off, the edge will be white where the first sand was dropped, green where the second, and the rest brown.

A colour of 2 shades may be made by using sand, then a moderately dark brown sprinkled, then more sand, and lastly a deeper shade of same colour.

A few still use the "finger-brush," a small brush about the size of a shaving

brush, made of stiff bristles cut squarely. They dip it into the colour, and then by drawing the finger across it jerk the colour over the edge. Another method is to use a larger brush, which, being dipped in the colour, is beaten on a stick or press-pin until the desired amount of sprinkle is obtained. But the best plan for an amateur is to use a nail-brush and a common wire cinder-sifter. Dip the brush in the colour and rub it in a circular direction over the cinder-sifter. This mode has the satisfactory result of doing the work quicker, finer, and more uniformly. The head, foredge and tail must be of exactly the same shade, and one end must not have more sprinkle on it than the other, and a set of books must have their edges precisely alike in tone and character.

Colours for Sprinkling.—Many dyes and colours that answer all purposes, may be purchased ready for instant use. Judson's dyes diluted with water are very good.

Plain Colouring.—The colours, having been well ground, are mixed with paste and a little oil, or glaire and oil. Then, with a sponge or brush, colour the whole of the edge. In colouring the foredge, the book should be drawn back so as to form a slope of the edge, so that when the book is opened a certain amount of colour will still be seen. It is often necessary to give the edges 2 coats of colour, and the first must be quite dry before the second tint is applied.

A very good effect may be produced by first colouring the edge yellow, and when dry, after throwing on rice, seeds, pieces of thread, or anything else according to fancy, sprinkle with some other dark colour. For this class body colour should always be used. This may be varied in many different ways.

Marbled Edges.—The edges of marbled books should correspond with their marbled ends. In London, few binders marble their own work, but send it out of the house to marblers, who do nothing but make marbled edges and paper. It is a process that may seem easy, but is very difficult to execute properly, and it costs but little to get it done.

The requisites are a long square wooden or zinc trough, about 2 in. deep, to hold the size for the colours to float on; about 16–20 in. long and 6–8 in. wide, will probably be large enough. Various colours are used, such as lake, rose, vermilion, king's yellow, yellow ochre, Prussian blue, indigo, some green, flake white, and lamp-black. The brushes should be of moderate size, and each pot of colour must have its own brush. Small stone jars are convenient for the colours, and a slab of marble and a muller for grinding them. The combs may be made with pieces of brass wire about 2 in. long, inserted in a piece of wood; several of these will be required with the teeth at different distances, according to the width of the pattern required to be produced. Several different sized burnishers, flat and round, will be required for giving a gloss to the work.

The first process in marbling is the preparation of the size on which the colours are to be floated. This is a solution of tragacanth, or, as it is commonly called, "gum dragon." If the gum is placed overnight in the quantity of water necessary, it will generally be found dissolved by the morning. The proportions can easily be learned by experience; the solution must be filtered through muslin or linen before use.

The colours are ground on the marble slab with a little water, as fine as possible; move the colour from time to time into the centre of the marble with a palette knife, and as the water evaporates add a little more. About 1 oz. of colour will suffice to grind at once, and it will take about 2 hours to do it properly.

Having everything at hand and ready, with the size in the trough, and water near; the top of the size is to be carefully taken off with a piece of wood the exact width of the trough, and the colour being well mixed with water and a few drops of ox gall, a little is taken in the brush, and a few very fine spots are thrown on.

If the colour does not spread out, but rather sinks down, a few more drops of

gall must be carefully added and well mixed up. The top of the size must be taken off as before described, and the colour again thrown on.

If it does not then spread out, the ground or size is of too thick consistency, and some clean water must be added, and the whole well mixed.

If the colour again thrown on spreads out, but looks rather greyish or spotty, the colour is too thick, and a little water must be added, but very carefully, lest the colour be made too thin. If the colour still assumes a greyish appearance when thrown on, the fault lies in the grinding, and it must be dried and again ground.

When the colour, on being thrown on, spreads out in very large spots, the ground or size is too thin and a little thicker size should be added.

If the colours appear all right on the trough, and when taken off on a slip of paper adhere to it, the size and colours are in perfect working order.

The top of the size must always be taken off with the piece of wood before commencing work, so that it be kept clean, and the colours must always be well shaken out of the brush into the pot before sprinkling, so that the spots may not be too large. The marbler must always be guided by the pattern he wishes to produce, and by a little thought he will get over many difficulties that appear of greater magnitude than they really are.

Spot Marble. — The size is first sprinkled with a dark colour, termed the "ground colour"; then follow the other colours, bearing in mind that the colour which has most gall will spread or push the others away, and this colour should in spot marbling be put on last.

With very little variation all the other kinds of marbling are done; but in every case where there are more books or sheets of the same pattern than the trough will take at once, the same order of colours must be kept, and the same proportion of each, or one book will be of one colour and the second entirely different.

Comb or Nonpareil Marble. — The colours are thrown on as before, but as fine as possible. Then if a piece of wood or wire be drawn backwards and forwards across the trough, the colours, through the disturbance of the size, will follow the motion of the stick. The comb is then drawn the whole length of the trough in a contrary direction. The wire in the comb will draw the colour, and produce what is termed "comb" or "nonpareil" marble.

Spanish Marble.—The ground colour is thrown on rather heavily, the others lighter, and the wavy appearance is caused by gently drawing the paper in jerks over the marble, thus causing the colour to form small ripples.

Other effects.—A few drops of turpentine put in the colours will give them a different effect, viz. causing the small white spots that appear on "shell marble."

There are various patterns, each being known by name: old Dutch, nonpareil, antique, curl, Spanish, shell. Specimen sheets of the various kinds might be kept as patterns for future reference.

Edges. — Edges are marbled, after making the desired pattern on the trough, by holding the book firmly, pressing the edge on the colour and lifting it up sharply. The foredge must be made flat by knocking the book on its back, but it is as well to tie the book between a pair of backing-boards, so that it may not slip, especially if large. Care must be taken with books that have many plates, or if the paper is at all of a spongy nature or unsized. If a little cold water be thrown on the edges, it will cause the colours to set better. In marbling writing paper, a sponge with a little alum water should be used to take off the gloss from the edge, occasioned by the cutting knife, and to assist the marbling colour to take better.

Paper is marbled in the same way by holding it at 2 corners, then gently putting it on the colour and pressing it evenly, but gently all over, so that the colour may take on every part. It must be lifted carefully, as the least shake by disturbing the size will spoil the regularity of the pattern. Paper should

be damped overnight and left with a weight on the top. When the paper has been marbled and is dry, a rag with a little beeswax or soap should be rubbed over it, so that the burnisher may not stick, and to give a finer gloss; this applies also to the edges in burnishing. Marble paper manufacturers burnish the paper with a piece of polished flint or glass fixed in a long pole working in a socket at the top, the other end resting on a table which is slightly hollowed, so that the segment of the circle which the flint takes is exactly that of the hollow table. The paper is laid on the hollow table, and the burnisher is worked backwards and forwards until the desired gloss is attained. By the best and latest method, the paper is passed between highly polished cylinders. It is more expensive, on account of the cost of the machinery, but ensures superior effect.

Sizing.—Paper should be sized after being marbled. The size is made by dissolving 1 lb. best glue in 5 gal. water with ½ lb. best white soap. This is put into a copper overnight, and on a low fire the next morning, keeping it constantly stirred to prevent burning. When quite dissolved and hot, it is run through a cloth into a trough, and each sheet is passed through the liquor and hung up to dry; when dry, burnished as already described. It is generally cheaper to buy the paper than to make it.

Following is a method of transferring the pattern from marble paper to the edges of books:—Wring the book up tightly in the press, the edge to be as flat as possible; cut strips of the best marble paper about 1 in. longer than the edge; make a pad of old paper larger than the edge of the book, and about ¼ in. thick; then get a piece of blotting paper and a sponge with a little water in; now pour on a plate sufficient spirits of salts (muriatic acid) to saturate the paper, which must be placed marble side downwards on the spirit (not dipped in it); when soaked, put it on the edge (which has been previously damped with a sponge), lay your blot paper on it, then your pad, now rap it smartly all over, take off the pad and blot, and look if the work is right, if so, take the book out, and shake the marble paper off; When dry, burnish.

Gilt Edges.—A gilt edge is the most elegant of all modes of ornamenting edges, and this branch of bookbinding has from time to time been so greatly extended, that at the present day there are many ways in which a book may have the edges gilt. Thus there are "plain gilt," then "gilt in the round"; again, some colour under the gold, for instance "gilt on red," or whatever the colour may be, red being mostly used, especially for religious books. Some edges are "tooled," and some have a gilt edge with landscape or scene appropriate to the book painted on the edge, only to be seen when the book is opened. "Marbling under-gilt" may also be used with good effect; but still better "marbling on gilt."

The room where gilt edge work is done should be neither dirty nor drafty, and the necessary materials are:—

The Gold Cushion.—This may be purchased ready for use, or it may be made by covering a piece of wood, about 12 in. by 6, with a piece of white calf, the rough side outwards, and padding with blotting paper and cloth. The pieces underneath should be cut a little smaller than the upper one, so that it will form a bevel at the edge, but quite flat on the top. The calf to be neatly nailed all round the edge. If the pile of the leather is too rough, it can be reduced with a piece of pumice, by rubbing on the calf with a circular motion.

Gold Knife.—This should be a long knife of thin steel, the blade about 1–1½ in. wide.

Burnishers.—These are made of agate, and can be purchased of any size. A flat one, and 2 or 3 round ones, will be found sufficient. They should have a very high polish.

Glaire Water or Size.—The white of an egg and a tea-cup full of water are well beaten together, until the albumen is perfectly dissolved; then allowed to stand for some hours to settle; after

which, it should be strained through a piece of old linen.

Scrapers.—Pieces of steel, with the edge or burr made to turn up by rubbing the edge flat over a bodkin or other steel instrument, so that when applied to the edge a thin shaving of paper is taken off. The beauty of gilding depends greatly on proper and even scraping.

Gold Leaf.—This is bought in books, the price, according to quality; most of the cheap gold comes from Germany. Use the best that can be had, it being in the end the cheapest, as cheap gold turns black in time by the action of the atmosphere.

To gild the edges, the book should be put into the press straight and on a level with the cheeks of the press between cutting-boards, the boards of the book being thrown back. The press should be screwed up very tightly, and any projection of the cutting-boards should be taken away with a chisel. If the paper is unsized or at all spongy, the edge should be sized and left to dry. This may be ascertained by wetting a leaf with the tongue: if spongy, the moisture will sink through as in blotting paper. The edge should be scraped quite flat and perfectly even, care being taken to scrape every part equally, or one part of the edge will be hollow or perhaps one side scraped down, and this will make one square larger than the other. When scraped quite smooth and evenly, a mixture of blacklead and thin glaire water is painted over the edge, and with a hard brush it is well brushed until dry.

The gold is now cut on the gold cushion. Lift a leaf out of the book with the gold knife, lay it on the gold cushion, breathe gently on the centre of the leaf to lay it flat; it can then be cut with ease to any size. The edge is now glaired evenly, and the gold is taken up with a piece of paper previously greased by drawing it over the head. The gold is then gently laid on the edge which has been glaired. The whole edge or end being done, it is allowed to get perfectly dry, which will occupy 2 hours.

Before using the burnisher on the gold itself, some gilders lay a piece of fine paper on the gold, and gently flatten it with the burnisher. Books are often treated in this manner: they then become "dull gilt." When intended to be bright, a waxed cloth should be gently rubbed over the surface 2 or 3 times before using the burnisher. The beauty of burnishing depends upon the edge presenting a solid and uniform metallic surface, without any marks of the burnisher.

The manner of burnishing is to hold a flat burnisher, where the surface is flat, firmly in the right hand with the end of the handle on the shoulder, to get better leverage. Work the burnisher backwards and forwards with a perfectly even pressure on every part. When both ends are finished, the foredge is proceeded with, by making it perfectly flat. It is better to tie the book, to prevent it slipping back. The foredge is gilt exactly in the same manner as the ends; it will return to its proper round when released from the press. This is done with all books in the ordinary way, but if the book is to have an extra edge, it is done "solid or in the round." For this way, the book must be put into the press with its proper round, and without flattening it, and scraped in that position with scrapers corresponding with the rounding. The greatest care must be taken in this kind of scraping that the sides are not scraped away, or the squares will be made either too large or lop-sided.

Gilt on Red.—The edges are coloured by fanning them out as explained in colouring edges, and when dry, gilt in the usual way; not quite such a strong size will be wanted, through there being a ground in the colour; nor must any blacklead be used. The edges must in this process be scraped first, then coloured and gilt in the usual way.

Tooled Edges.—The book is gilt as usual, then, while in the press, stamped or worked over with tools that are of some open character; those of fine work being preferable. Some design should

be followed out according to the fancy of the workman.

The tools must be warmed slightly, so that the impression may be firm; the foredge should be done first. Another method is to tool the edge before burnishing, or the different portions of the tooling may be so managed in burnishing that some parts will be left bright and standing in relief on the unburnished or dead surface.

Painted Edges.—The edge is fanned out and tied between boards, and whilst in that position some landscape or other scene, either taken from the book itself or appropriate to the subject of it, is painted on the foredge, and when quite dry it is gilt on the flat in the usual manner. This work of course requires an artist well skilled in water-colour drawing.

After the edges have been gilt by any of the foregoing methods, the rounding must be examined and corrected, and the book should be put into the standing press for 2–3 hours, to set it. The whole of the edges should be wrapped up with paper to keep them clean during the remainder of the process of binding. This is called "capping up."

Head - banding.—Few binders work their own head-bands; the majority use the machine-made head-band. These can be purchased of any size or colour, at a moderate price.

Head-banding done by hand is really only a twist of different coloured cotton or silk round a piece of vellum or catgut fastened to the back at every half-dozen sections. If the head-band is to be square or straight, the vellum should be made by pasting 2 or 3 pieces together. Damp the vellum previously, and put it under a weight for a few hours to get soft. Vellum from old ledgers and other vellum-bound books is mostly used. The vellum, when quite dry and flat, is cut into strips just a little under the width of the squares of the books, so that when the book is covered, the amount of leather above the head-band and the head-band itself will be just the size or height of the square.

If, however, a round head-band is chosen, catgut is taken on the same principle with regard to size, and this is further advanced by using 2 pieces of catgut, generally one being smaller than the other, and making with the beading 3 rows. To explain how the head-band is worked is a difficult task; yet the process is very simple. The great difficulty is to get the silks to lie close together, which they will not do if the twist or beading is not evenly worked. This requires time and patience to accomplish. The hands must be clean, or the silk will get soiled; fingers must be smooth, or the silk will be frayed.

Supposing a book is to be done in 2 colours, red and white. The head-band is cut to size, the book is, for convenience, held in a press, or a plough with the knife taken out, so that the end to be head-banded is raised to a convenient height. The ends of the silk or cotton are joined together, and one, say the red, is threaded through a strong needle. This is passed through the back of the book, at about the centre of the second section, commencing on the left of the book, twice, and a loop is left. The vellum is put into this loop, and the silk is drawn tight; the vellum will then be held fast. The white is now twisted round the red once, and round the head-band twice; the red is next taken in hand, and twisted round the white once and the head-band twice. This is done until the whole vellum is covered. The needle must be passed through the back at about every 8 sections to secure the head-band. The beading is the effect of one thread being twisted over the other, and the hand must be kept exactly at the same tightness or tension, for if pulled too tightly the beading will go underneath, or be irregular. The fastening off is done by passing the needle through the back twice, the white is then passed round the red and under the vellum, and the ends are tied together.

Three Colours Plain.—This is commenced in the same way as with 2, but great care must be taken that the silks

are worked in rotation, so as not to mix or entangle them. The silks must be kept in the left hand, while the right twists the colour over or round; and as each is twisted round the vellum, it is passed to be twisted round the other two. In fastening off, both colours must be passed round under the vellum, and fastened as with the 2-colour pattern.

Head-bands may be worked intermixed with gold or silver thread, or the one colour may be worked a number of times round the vellum, before the second colour has been twisted, giving it the appearance of ribbons going round the head-band.

Stuck-on head-bands may be made at little expense, by using striped calico for the purpose. A narrow stripe is to be preferred of some bright colour. The material must be cut into lengths of about 1½ in. wide, with the stripes across. Cords of different thickness are then cut somewhat longer than the calico, and a piece of the cord is fastened by a nail at one end on a board of sufficient length. The calico is then pasted and laid down on the board under the cord; the cord, being held tightly, may be easily covered with the striped calico, and rubbed with a folder into a groove.

When this is dry, the head and tail of the book are glued, and the proper piece of the head-band is put on. Or the head-band may be purchased, as before stated, worked with either silk or cotton ready for fastening on, for 2*s.* 3*d.* to 4*s.* 6*d.* a piece of 12 yd., according to the size required. The amateur will find this far better than working his own head-bands, but it has the disadvantage of not looking so even as a head-band properly worked on the book.

After the head-band has been put on or worked, the book is "lined up" or "got ready for covering."

Preparing for Covering.—Nearly all modern books are bound with hollow backs, except where the books are sewn for flexible work, or otherwise meant to have tight backs.

The head-band is first set with glue, if worked, by glueing the head and tail, and with a folder the head-band is made to take the same form as the back. This is done by holding the book in the left hand with its back on the press, then a pointed folder held in the right hand is run round the beading 2 or 3 times to form it; the silk on the back is then rubbed down as much as possible to make all level and even, and the book is allowed to dry. When dry, it is put into the laying press to hold it, and the back is well glued all over; some paper, usually brown, is now taken, the same length as the book, put on the back and rubbed down well with a thick folder: a good-sized beef rib is as good as anything. The overplus of the paper is cut away from the back, except the part projecting head and tail. A second coat of glue is put on the top of the brown paper and another piece is put on that, but not quite up to the edge on the left side. When this is well rubbed down, it is folded evenly from the edge on the right side over to the left; the small amount of glued space left will be found sufficient to hold it down. The top is again glued, folded over from left to right, and cut off level by folding it back and running a sharp knife down the fold. This is what is generally termed "two on and two off," being 2 thicknesses of paper on the back and 2 for the hollow; but thin or small books need only have 1 on the back and 2 for the hollow. Thick or large books should have more paper used in proportion to their size. Books that have been over-cast in the sewing should have rather a strong lining up, so that there be not such a strain when opened. When the whole is dry, the overplus of the paper, head and tail, is cut off close to the head-band.

The better the paper used the easier will be the working of it. Old writing or copy-book paper will be found to be as good as any, but good brown paper is mostly used.

The book is now ready for putting the bands on. These are prepared beforehand by sticking with glue 2 or 3 pieces of leather together or on a piece of paper, well pressing, and allowing to dry under pressure. The paper must be glued

twice, allowing each coat to dry before glueing again. It should then be put on one side for future use, and when wanted, the proper thickness is chosen and cut into strips of a width to correspond with the size of the book. The book is marked up, 5 bands being the number generally used, leaving the tail a little longer than the other portions. The strips of band are then moistened with a little hot water to cause the glue upon the paper to melt. Each piece is then fixed upon the back just under the holes made with the compasses in marking up. This will be found to be a far better plan than to first cut the strips and then glue them. By the latter plan, the glue is liable to spread upon the side, where it is not wanted, and if the book has to be covered with light calf, it will certainly be stained black: be careful that all glue is removed from the back and sides before attempting to cover any book with calf.

When dry, the ends of the bands are cut off with a bevel, and a little piece of the boards from the corners nearest the back is also taken off on the bevel, that there may not be a sharp point to fret through the leather when the book is opened. This is also necessary, so that the head-band may be properly set. A sharp knife should be inserted in the hollow, and should separate it from the back at head and tail on each side so far as to allow the leather to be turned in. Morocco may have the back glued, as it will not show through, and will facilitate the adhesion of the leather.

Flexible Work.—This is not lined up. The leather is stuck directly upon the book; the head-band is set as before explained, and held tight by glueing a piece of fine linen against it, and when quite dry, the overplus is cut away, and the back is made quite smooth. The bands are knocked up gently with a blunt chisel to make them perfectly straight, being first damped and made soft with a little paste to facilitate the working and prevent the thread from being cut. Any holes caused by sawing-in, in previous binding, must be filled up with a piece of frayed cord, pasted. Any holes thus filled up must be made quite smooth when dry, as the least unevenness will show when the book is covered.

In "throw up" backs, or in "flexible not to show," a piece of thin linen or stuff called "mull" (muslin) is glued on the back first, and one piece of paper on the top. For the hollow, 3, 4, or even 5 pieces are stuck one on the other, so that it may be firm; whilst the book itself will be as if it had a flexible back. The bands, if any, are then fastened on, and the corners of the boards are cut off. It is then ready for covering. "Mock flexible" has generally one piece of paper glued on the back, and when marked-up, the bands are put on as before, and the book is covered.

Covering.—Books are covered according to the fancy of the binder or customer. The materials used at the present day are—leather of all sorts, parchment or vellum, bookbinders' cloth, velvet, needle-work, and imitation leather, of which various kinds are manufactured, such as leatherette and feltine.

Each kind requires a different manner of working or manipulation. For instance, a wet calf book must not be covered in the same manner as a velvet one.

Under the class of leather, come moroccos of all kinds; russia; calf, coloured, smooth and imitation; roan, sheep and imitation morocco.

The morocco cover, indeed any leather cover, is cut out by laying the skin out on a flat board, and having chosen the part or piece of the skin to be used, the book is laid on it and the skin is cut with a sharp knife round the book, leaving a space of about $\frac{3}{4}$ in. for an 8vo, and more or less according to the size of the book and thickness of board, for turning in. The morocco cover should now have marked upon it with a pencil, the exact size of the book itself, by laying the book on the cover, and running the point of a blacklead pencil all round it. The leather must then be "pared," or shaved round the edges, using the pencil marks as a guide. This paring process is not difficult, es-

pecially if a French knife is used, such as may be purchased at Eadie and Son's, the chief point being that a very sharp edge is to be kept on the knife, and that the "burr" is on the cutting edge. The knife is held in the right hand, placing 2 fingers on the top with the thumb underneath. The leather must be placed on a piece of marble, lithographic stone, or thick glass, and held tightly strained between finger and thumb of the left hand. Then, by a series of pushes from the right hand, the knife takes off more or less, according to the angle given. The burr causes the knife to enter the leather; if the burr is turned up, the knife will either not cut or run off. If the knife is held too much at an angle, it will go right through the leather. The leather should from time to time be examined, by turning it over, to see if any unevenness appears, for every cut will show. Special attention should be given to where the edges of the board go. The turning in at the head and tail should be pared off as thin as possible, as there will be twice as much thickness of leather on the back where turned in, the object of this care being that it must not be seen. The morocco cover should now be wetted well, and grained up by the hand or a flat piece of cork. This is done by gently curling it up in all directions; and when the grain has been brought up properly and sufficiently, the leather should be pasted on the flesh side with thin paste, and hung up to dry. Should the leather be "straight grain," it must only be creased in the one direction of the grain, or if it is required to imitate any old book that has no grain, the leather should be wetted as much as possible, and the whole of the grain rubbed out by using a rolling-pin with even pressure.

Russia and calf require no setting up of the grain, but russia must be well rolled out with the rolling-pin.

When the cover (morocco) is dry, it is well pasted, and the squares of the book are set, so that each side has its proper portion of board projecting. The book is then laid down evenly on the cover, which must be gently drawn on; the back is drawn tight by placing the book on its foredge and pulling the skin well down on the back. The sides are next drawn tight, and the bands are pinched well up with a pair of "band nippers." The 4 corners of the leather are cut off with a sharp knife in a slanting direction, a little paste is put on the cut edge, and the operation of turning in may be commenced.

The book is held on its edge, either head or tail, with a small piece of paper put close to the head-band to prevent any paste soiling the edge or head-band, and with the boards extended, the hollow is pulled a little away from the back, and the leather is neatly tucked in. The leather is next tightly brought over the boards and well rubbed down, both on the edge and inside, with a folding-stick, but on no account must the outside be rubbed, or the grain will be taken away. The foredge is treated in like manner, by tucking the corners in for strength. The head-band is set by tying a piece of thread round the book, between the back and the boards, in the slots cut out from the corners of the boards; this thread must be tied in a knot. The book being held in the left hand, resting on its end, the leather is drawn with a pointed folding-stick, as it were, towards the foredge, and flattened on the top of the head-band. When this is done properly, it should be exactly even with the boards, and yet cover the head-band, leaving that part of the head-band at right angles with the edge exposed. A little practice will indicate what amount of leather is to be left out from the turning in, so that the head-band can be neatly covered. The perfection in covering a book depends upon the leather being worked sharp round the boards, but with the grain almost untouched.

Paste should be always used for all kinds of leather; but leather with an artificial grain should be glued, the turning in being pasted. The glue gives more body to the leather, and thus preserves the grain. White

morocco should be covered with paste made without alum, which turns it yellow. If the leather is washed with lemon-juice, instead of vinegar, when finishing, the colour will be much improved.

Russia leather is pared in the same way as morocco. It should be damped and rolled with a rolling-pin before covering.

Calf, either coloured or white, need be pared only round the head-band; it should be covered with paste, and the book washed, when covered, with a clean damp sponge. In putting 2 books together, when of calf of 2 different colours, a piece of paper should be placed between, as most colours stain each other, especially green. Care should be taken to finger calf as little as possible; whilst wet, touching it with iron tools, such as knives and band nippers, will cause a black stain. Morocco will bear much handling.

Vellum or Parchment.—The boards should be covered with white paper, to avoid any darkness of the board showing through. The vellum or parchment should be pared at head and tail, and the whole well pasted and allowed to stand for a short time, so that it be well soaked and soft. The book should then be covered, but the vellum must not on any account be stretched much, or when dry it will draw the boards up to a remarkable extent. If the book be pressed, the vellum will adhere better. Old binders took great pains in covering their white vellum books. The vellum was lined carefully with white paper and dried before covering: this in some degree hindered the shrinking in drying, and enabled the workman to give the boards a thin and even coat of glue, which was allowed to dry before putting on the covering.

Roan is covered with glue and turned in with paste. Head and tail only need be pared round the head-band.

Cloth is covered by glueing the cover all over and turning in at once: glueing one cover at a time, and finishing the covering of each book before touching the next.

Velvet should be covered with clean glue not too thick; first glue the back of the book and let that set before the sides are put down. The sides of the book should next be glued, and the velvet laid down, turned in with glue. The corners should be very carefully cut or they will not meet, or cover properly when dry. When the whole is dry, the pile may be raised, should it be finger marked, by holding the book over steam, and, if necessary, by using a brush carefully.

Silk and satin should be lined first with a piece of thin paper cut to the size of the book, glued with thin clean glue, rubbed down well, and allowed to get dry, before covering the book. When dry, cover it as with velvet.

Half-bound Work.—The book has its back, a part of the sides, and the corners covered with leather. The sides are, after the leather is perfectly dry, covered either with cloth or paper according to fancy, turned over the boards as with leather. The book is then pasted down. Before the paper is put on the sides, all unevenness of the leather is pared away. This style has come very much into reputation lately on account of its economy; the amount of leather required is less, and the work is as strong and serviceable as in a whole-bound book. It will be better if the back be finished before the corners are put on, as there is great likelihood that the corners may get damaged to some extent during the process of finishing. The outside paper may either match the colour of the leather, or be the same as the edge or end-papers.

Pasting down.—This is to cover up the inside board by pasting down the end-papers to the boards.

The white or waste leaf, that has till this process protected the end-papers, is now taken away or torn out. The joint of the board must be cleaned of any paste or glue that may have accumulated there, by passing the point of a sharp knife along it, so that when the end is pasted down, the joint will be quite straight and perfectly square.

Morocco books should be filled in

with a smooth board or thick paper, the exact substance of the leather. This thickness must be carefully chosen, and one edge be cut off straight, and stuck on the inside of the board very slightly, in fact only touching it in the centre with a little glue or paste, just sufficient to hold it temporarily. It must be flush with the back-edge of the board. When dry, the paper or board is marked with a compass about $\frac{1}{2}$ in. round, and both paper and leather are cut through at the same cut with a sharp knife. The overplus board will fall off, and the outside of the leather may be easily detached by lifting it up with a knife. The paper or board, which will now fit in exactly, should be glued and well rubbed down with a folding-stick, or it may be put into the standing press if the grain of the morocco is to be polished, but not otherwise.

Morocco books only have morocco joints, thus made. Morocco of the same colour is cut into strips the same length as the book, and about $1\frac{1}{2}$ in. in breadth for 8vo; a line is drawn or marked down each strip about $\frac{1}{2}$ in. from its edge, with a pencil or folder, as a guide. The leather is pared from the mark to a thin edge on the $\frac{1}{2}$-in. side, and the other side is pared as thin as the leather turned in round the board, so that there will be 2 distinct thicknesses on each piece: the larger half going on the board to correspond with the leather round the 3 sides, and the smaller and thinly pared half going in the joint and edge on to the book. The end-papers, only held in with a little paste, are lifted out from the book, the leather, well pasted, is put on the board, so that the place where the division is made in the leather by paring will come exactly to the edge of the board; the thin part should then be well rubbed down in the joint, and the small thin feather edge allowed to go on the book.

Great care must be taken to rub the whole down well, that it may adhere properly; the grain need not be heeded. With regard to the overplus at the head and tail, there are two ways of disposing of it: first, by cutting both leathers slanting through at once, and making the two meet; or, secondly, by cutting the cover away in a slant and doing the same to the joint, so that the 2 slant cuts cover each other exactly. This requires very nice paring, or it will be seen in the finishing. The book should be left till quite dry, which will take some 5–6 hours. The boards are then filled in by the same method, and the end-papers are fastened in again properly.

Cloth Joints.—If the cloth has been stuck in when the ends were made, after cleaning all unevenness from the joints, the boards are filled in as above, and the cloth joint is stuck down with thin glue, and rubbed down well. The marble paper may now be put on the board by cutting it to a size, a little larger than the filling in of the board, so that it may be well covered. When cloth joints are put in, the board paper is generally brought up almost close to the joint; but with morocco joints, the space left all round must be even.

Calf, Russia, &c.—After having cleaned the joint, the leather is marked all round a trifle larger than the size intended for the end-papers to cover. Then with a knife, the leather is cut through in a slanting direction by holding the knife slanting. The boards should be thrown back to protect the leather, and the book placed on a board of proper size, so that both book and board may be moved together, when turning round. When the leather is cut, a piece of paper should be pasted on the board to fill up the thickness of the leather, and to curve or swing the board back; the boards otherwise are sure to curve the contrary way, especially with calf. When this lining is dry, the end-papers may be pasted down.

There are 2 methods of doing this. In the most exact, the paper is pasted all over, especially in the joint, and the paper being held in the left hand, is well rubbed down, more particularly in the joint. The paper is marked all round (head, foredge, and tail) with a pair of

compasses to the width required for finishing inside the board. With a very sharp knife, the paper is to be cut through to the depth of the paper only, by laying the straight-edge on the marks made by the compasses. This has the advantage of procuring an exact margin round the board; but it must be done quickly, or the paper will stick to the leather round the board from the paste getting dry, the leather absorbing the watery particles in the paste. The other way is to lay the paper back, and down on the board, and then to mark it. A tin is then placed between the book and paper, and the paper is cut to the marks made. The paper is then pasted down as above. When pasted down, the book should be left standing on its end, with boards left open until thoroughly dry, which will be about 6 hours. A tin should be kept especially for cutting on, and the knife must be as sharp as possible. This latter method is used for all half bindings.

Hand-finishing. — Hand-finishing is really an art. The finisher should be able to draw, or at least have some knowledge of composition, and also know something about the harmony of colours. Taste has no small influence. It is better to finish books plainly, rather than put on more gold than is necessary. Let the tools be always in keeping with the book, both in size and character. Large ones should be used only on a large book, and those of less size for smaller works. A book on Natural History should have a bird, insect, shell or other tool indicative of the contents. A flower should be used on works on Botany, and all other works should be treated in the same emblematical manner. In lettering, see that the letters are of a size proportionate to the book—legible but not too bold. They should neither be so large as to prevent the whole of the title being read at one view, nor so small as to present a difficulty in ascertaining the subject of a book when on the shelf. Amongst a large number of books, there should be an agreeable variety of styles, so that the effect may be in harmony with the colours around, and produce as pleasing a contrast as possible.

Tools and Materials.—These embrace rolls, fillets, pallets, centre and corner tools of every possible class and character; type of various sizes for lettering books or labels. The type may be either of brass or printers' metal; if the latter, care must be taken that it be not left at the fire too long, or it will melt. Type-holders are made to fit the respective sizes, but one or two with a spring side, adjusted by screw, will be found convenient for any type. In England it is the custom to letter books with hand letters, each letter being separate and fixed in a handle. Doubtless these will in time be laid aside, and the type and type-case will be adopted.

Of polishing-irons 2 are necessary—one for the sides and one for the backs. Often a third is kept for polishing the board end-papers when pasted down.

The gold-rag, to wipe off the surplus gold from the back or side of a book, should have a little oil well worked into it, so that the gold may adhere to and remain in it. This rag when full of gold will be of a dirty yellow, and may then be melted down by a gold-refiner, and the waste gold recovered.

Rubber, cut up very small — the smaller the better—and steeped in turpentine so as to make it as soft as possible, is used for clearing away any gold not taken off by the gold-rag. This should also be melted down when full.

Sponges are wanted—large ones for paste-washing, smaller for glairing and sizing.

Glaire may be purchased already prepared, or it may be made from white of egg very carefully beaten up to a froth with a whisk. In breaking the egg, care must be taken not to let any of the yolk get amongst the white. A little vinegar should be mixed with the white before beating up, and a drop of ammonia, or a grain or two of common table salt, or a small piece of camphor, will in some measure prevent it from turning putrid, as it is liable to do. Some workmen keep a stock of "good

old glaire," as they term it, by them, fancying that it produces better work; but this is a mistaken notion. When well beaten, allow the glaire to stand for some hours, and then pour the clear liquid into a bottle for use.

Cotton wool is used for taking the gold leaf up and pressing it firmly on the leather.

Varnish should be used only on that part where glaire has been applied and has afterwards been polished, the object being to restore brilliancy and preserve the leather from the ravages of insects attracted by the glaire. These pests do great damage to the covers of books prepared with glaire, taking away the surface of the leather and spoiling the appearance. Varnish may be purchased at all prices; use only the best, and be very sparing with it.

A small pair of spring dividers, some lard, sweet oil, and a finishing stove, are also required. Before gas was introduced, use was made of the now almost extinct charcoal fire. A bookbinders' gas stove can now be purchased at prices varying with the size, which can be used to warm glue, make paste, and heat tools for finishing, besides a hundred other purposes. Where cost is an object, or where gas is not obtainable, charcoal may still be used. Any old tin may be utilised: make a number of large holes through the sides; fill it with some live charcoal, and place a perforated tin plate on the top. It will keep alight for hours, and impart quite enough heat for any purpose required. This primitive stove, however, must be placed on a stand or on a piece of thick iron, lest it become dangerous.

Styles.—Finishing is divided into 2 classes—"blind," "antique," or as it is sometimes called, "monastic"; and "gold-finished."

The term antique is mostly known in the trade; and when morocco antique or calf antique is mentioned, it means that the whole of the finishing is to be done in blind tooling. Not only this, but that the boards should be very thick and bevelled, and the edges either dull gilt or red, or gilt over red. This class of work is used extensively for religious books. A gold line introduced and intermixed with blind work gives a great relief to any class of antique work.

It is not necessary that a special set of tools be kept for antique work, although some would look quite out of keeping if worked in gold. As a general rule, antique tools are bold and solid, such as Venetian tools, whilst those for gold work are cut finer and are well shaded. The greater number work equally well in gold and in blind; but when a special style has to be followed, the various tools and their adaptation to that style must be studied.

The general colour of blind work is dark brown, and the proper way of working these antique tools is to take them warm and work them on the damp leather a number of times, thus singeing the surface only, until it has assumed its proper degree of colour. Antique work as a decoration, requires quite as much dexterity and care as gold work. Every line must be straight, the tools worked properly on the leather, both in colour and depth; and as the tools have to be worked many times on the same spot, it requires a very steady hand and great care not to double them. Some consider blind work as preparatory to gold work, and that it gives experience in the method of handling and working the various tools; and the degree of heat required for different leathers without burning them through. The leathers on which this work is mostly executed are morocco and calf.

In finishing the back of a book, it must always be held tightly in a small hand press, termed a "finishing press." This is of the same kind as a laying press, only much smaller, and is screwed up by hand. When in the press, mark the head and tail as a guide for the pallets by running a folding-stick along the edge of a piece of parchment or pasteboard held by the fingers and thumb of the left hand against the sides of the volume across the back at the proper place. When several books of the same character and size are to range

together, the backs are compassed up so that the head and tail lines may run continuous when finished. In using the pallet, hold it firmly in the right hand, and let the working motion proceed from the wrist only, as if it were a pivot. It will be found rather difficult at first to work the pallets straight over the back and even to the sides of the bands, but after a little practice it will become easy to accomplish.

Morocco flexible work, as a rule, has blind lines, a broad and a narrow one, worked close to the bands. Damp the back with a sponge and clean water, and work it evenly into the leather with a hard clean brush. Take a pallet of the size suitable to the book, warm it over the stove, and work it firmly over the back. As the leather dries, make the pallet hotter; this will generally be found sufficient to produce the required dark lines. Sometimes it will be necessary to damp the different places 2 or 3 times in order to get the proper colour in the blind tooling.

The pallets will have a tendency to stick to the leather and possibly burn it. To obviate this, take 1¼ oz. white wax, and 1 oz. deer fat or lard, place them in a pipkin over a fire or in a warm place, so that they may be well mixed together; when mixed, allow to cool. Rub some of this mixture upon the rough or fleshy side of a piece of waste morocco, and when working any tools in blind, rub them occasionally over the prepared surface. This mixture will be found of great service in getting the tools to slip or come away from the leather in working. Lard alone is sometimes used, but this mixture will be found of greater service to any finisher, and the advantage of adding the wax will be apparent.

The lines impressed on the back must now have their gloss given to them. This is done by "giggering" the pallets over them. Make the pallet rather hot, rub it over the greased piece of leather, and work it backwards and forwards in the impression previously made. Great care must be taken that the pallet be kept steadily in the impressions already made, or they will be doubled. The back is now ready for lettering, as described farther on.

To blind tool the side of a book it must be marked with a folder and straight-edge, according to the pattern to be produced; and as a guide for the rolls and fillets to be used. These lines form the ground plan for any design that has to be worked. Damp the whole of the side with a sponge, and brush it as before directed; then work the fillets along the lines marked. Run them over the same line 2 or 3 times. When dry, make the fillet immovable by driving a wooden wedge between the roll and fork, and gigger it backwards and forwards to produce the gloss. If tools are to be worked, make them slightly warm, and, as the leather dries, make the tool hotter and hotter. This must be repeated as often as necessary until the desired depth of colour and gloss is obtained. In using a roll that has a running or continuous pattern, a mark should be made upon the side with a file, at the exact point that first comes in contact with the leather, so that the same design may always come in the same place in the repeated workings. It is impossible for a roll to be cut so exactly that it may be worked from any point in the circumference without doubling it. Blind work is done in the same way whether in using a small tool or a large roll. The leather must be damped and repeatedly worked until the depth of colour is obtained. It is then allowed to dry, and re-worked to produce the gloss. The beauty of blind work consists in making the whole of the finishing of one uniform colour, and in avoiding the fault of having any portion of the work of lighter tint than the rest.

Gold Work.—This is far more complicated than blind or antique work, so that it is better to practise upon some spare pieces of roan, calf, and morocco, before attempting to finish a book. Gold work is not more difficult than blind tooling, it is only more complicated. The different kinds of leather require such different degrees of heat, that what would fail to make the gold adhere upon one leather would burn through another.

The various colours require different degrees of heat; as a rule, light fancy colours need less than dark.

The medium by which the gold is made to adhere to the leather is used in 2 ways—wet and dry. The wet is used for leather, the dry for velvet, satin, silk, and paper.

The wet medium is again divided into 2 classes, one for non-porous and another for porous leather. Morocco is the principal of the non-porous leathers, with roan and all other imitation morocco. The porous varieties consist of calf of all kinds, russia and sheep.

The non-porous leathers need only be washed with thin paste water or vinegar and glaired once; but if the glaire be thin or weak, it will be necessary to give them a second coat of glaire.

The porous varieties must be paste-washed carefully, sized all over very evenly, and glaired once or twice; care being taken that the size and glaire be laid on as evenly as possible.

All this, although apparently so simple, must be well kept in mind, because the great difficulty is in not knowing the proper medium for the various leathers, and one book may be prepared too much, while another may have a deficiency. As a consequence one book will be spoilt by the preparation cracking, and the gold will not adhere to the other. By following the directions here given, the gold will adhere without much trouble, beyond the practice necessary in becoming accustomed to an accurate use of the various tools.

Suppose that a half-morocco book is to be neatly finished and lettered. Take a broad and narrow pallet of a suitable and proper size, work it against the bands in blind as a guide for finishing in gold. As the impression need be but very slight, warm the pallet on the gas stove but very little. Choose some suitable tool, as a centre piece to go between the bands. Work this also lightly on the back exactly in the centre of each panel, as truly as possible and perfectly straight. A line made previously with a folding-stick along the centre of the back will greatly assist in the working of a tool in its proper position. Wash the back with vinegar, and brush it well with a hard brush to disperse the moisture and drive it equally into the leather; some use paste-water for this purpose instead of vinegar. Paste-water has a tendency to turn grey in the course of time: this is avoided in using vinegar, which also imparts freshness to the morocco, and keeps it moist a longer time, very desirable in finishing.

The impressions made by the broad and narrow pallet and the centre tool are pencilled in with glaire; when dry, pencil in another coat; allow this again to dry, then rub them very slightly with a piece of oiled cotton wool. Take a leaf of gold from the book, and spread it out evenly on the gold cushion; cut it as nearly to the various shapes and sizes of the tools as possible. Take one of the pieces of gold upon a large pad of cotton wool, greased slightly by drawing it over the head. (There is always a sufficient amount of natural grease in the hair to cause the gold to adhere to cotton drawn over it). Lay the gold gently but firmly on the impressed leather. See that the whole of the impression be covered, and that the gold be not broken. Should it be necessary to put on another piece of gold leaf, gently breathing on the first will make the second adhere.

When all the impressions are covered with gold leaf, take one of the tools heated to such a degree that when a drop of water is applied it does not hiss but dries instantly; work it exactly in the blind impressions. Repeat this to the whole of the impressions, and wipe the overplus of gold off with the gold-rag. The impressions are now supposed to be worked properly in gold; but if there are any parts where the gold does not adhere, they must be re-glaired and worked in again. A saucer should be placed near at hand with a piece of rag or a sponge and water in it, to reduce any tool to its proper heat before using. If the tool be used too hot, the gold impression will be dull—if too cold, the gold will

not adhere. To use all tools of the exact degree of heat required is one of the experiences of the skilled workman.

The back is now ready for the title. Set up the words in a type-case, with type sufficiently large and suitable to the book. The chief word of the title should be in somewhat larger size than the rest, the others diminishing, so that a pleasant arrangement of form be attained. In order to adjust the length of the words, it may be necessary to "space" some of them—that is, to put between each letter a small piece of metal called a "space." Square the type, or make the face of the letters perfectly level by pressing the face of them against a flat surface before tightening the screw. They must be exactly level one with another, or in the working some of them will be invisible. Screw the type-case up, warm it over the finishing stove, and work the letters carefully in blind as a guide. Damp the whole of the lettering space with vinegar. When dry, pencil the impressions in twice with glaire. Lay the gold on and work them in gold.

But with lead type and a spring type-case (more suitable for amateurs on account of its relative cheapness, and the case fitting itself to the different sizes of the type) the latter must be warmed before the type is put in. The heat of the case will impart sufficient heat for the type to be worked properly. If the case and type be put on the stove, the type will probably be melted if not watched very narrowly. Hand letters are letters fixed in handles and each used as a single tool. The letters are arranged in alphabetical order round the finishing stove, and as each letter is wanted it is taken from the order, worked, and replaced. They are still very much used in England, but where several books are to have the same lettering, brass type is very much better. It does its work more uniformly than hand letters, however skilfully used.

When this simple finishing can be executed properly and with ease, a more difficult style may be attempted, such as a "full gilt back." This is done in 2 ways, a "run-up" back and a "mitred" back. As a general rule, morocco is mitred. Place the book on its side, lift up the millboard and make a mark at head and tail on the back, a little away from the hinge of the back. Then with a folder and straight-edge mark the whole length of the back: this is to be done on both sides. Make another line the whole length down the exact centre of the back. With a pair of dividers, take the measurement of the spaces between the bands, and mark the size at head and tail for the panels from the top and bottom band; with a folder and strip of parchment make a line across the back, head and tail, at the mark made by the dividers.

Work a thin broad and narrow pallet alongside the bands in blind. Prepare the whole of the back with vinegar and glaire, but lay the glaire on with a sponge. When dry, lay the gold on, covering the whole of the back with it, and mending any breaks. For mitreing, take a 2-line pallet that has the ends cut at an angle of 45°, so that the join at that angle may be perfect. Work this on the side at the mark made up the back, and up to the line made in blind across the back. Repeat this to each panel. The 2-line pallet must be worked across the back and up to the lines made in gold, the cutting of the pallet at the angle will allow of the union or mitre, so that each panel is independent of the other. There will be spaces left at head and tail, which may be filled up with any fancy pallet or repetition of tools. The corners should be in keeping with the centre, and large enough to fit the panel. Work these from the sides of the square made, or from the centre of the panel, as will be found most convenient according to the thickness of the book and style of finishing, and then fill in any small stops. When the whole is done, rub the gold off with the gold-rag, and use the rubber if necessary. The title is put on in the manner before described.

It is not always necessary that the

finishing be done in blind first. One accustomed to finishing finds that a few lines marked previously with a folding-stick are all that is required. When working the title, a thread of silk drawn tightly across the gold produces a sufficient line, and is the only guide that an experienced workman requires.

To finish a side, make a mark with the folder and straight-edge as a guide for rolls or fillets. Prepare the leather, as before described, where the ornamentation is to come; but if the pattern is elaborate, it must be worked first in blind. As a greater facility, take a piece of paper of good quality and well sized. Draw the pattern on the paper, and if any tools are to be used, hold them over the gas flame; this will smoke them so that they may be worked on the paper in black. When the pattern is complete in every detail, tip the 4 corners of the paper with a little paste, then work the pattern through the paper on to the leather, using the various sized gouges as the scrolls require, and a single line fillet where there are lines. Work thus the complete pattern in blind. This being done completely, take the paper off from the 4 corners, place it on the other side, and work it in the same way. Prepare the leather with vinegar, and pencil the pattern out with glaire. If the whole side be glaired with a sponge, it will leave a glossy appearance that is very undesirable. The whole side is now laid on with gold, and the pattern is worked again with the warm tools, in the previous or blind impressions.

The inside of a book is generally finished before the outside. This should be done as neatly as possible, carefully mitreing the corners when any lines are used. Most frequently a roll is employed, thus saving a great deal of time. A style was introduced in France called "doublé," the inside of the board being covered with a coloured morocco different from the outside, instead of having board papers. This inside leather was very elaborately finished; generally with a "dentelle" border, while the outside had only a line or two in blind. It is a style which, although very good in itself, has quite died out with us, so many prefer to see the finishing to having it covered up when the book is shut.

The edges of the boards and the head-bands must be finished either in gold or blind, according to fancy, and in keeping with the rest of the embellishment. A fine line worked on the centre of the edge of the board by means of a fillet looks better, and of course requires more pains than simply running a roller over it. If it is to be in gold, simply glairing the edge is sufficient. Lay on the gold, and work the fillet carefully. Place the book on its ends in the finishing press to keep it steady, or it will shake and throw the fillet off. If a roll is used, take the gold up on the roll, grease it first a little, by rubbing the gold-rag over the edge to make the gold adhere. Then run the roll along the edge of the boards; the kind generally used for this purpose is called a "bar roll"—that is, having a series of lines running at right angles to the edge of the roll.

Imitation morocco is generally used for publishers' bindings, where books are in a large number and small in price; and the finishing is all done with the blocking press. To finish this leather by hand, it is advisable to wash it with paste-water and glaire twice.

Roan is generally used for circulating library work, and is very seldom finished with more than a few lines across the back and the title. This leather is prepared with paste-wash and glaire, and, when complete, varnished over the whole surface.

Inlaid Work. — Inlaid, or mosaic work, is used only in the higher branches of bookbinding. Formerly books were not inlaid, but painted with various colours. Grolier used a great deal of black, white, and green. Tuckett employed a method of extracting one colour from leather and substituting another by chemical action, thus:— Take dark chocolate colour, trace the design thereon, and pick it out or pencil it in with suitable chemicals, say

dilute nitric acid; this will change the chocolate, leaving the design a bright red on a chocolate ground.

To lay on the various colours with leather is, no doubt, by far the better plan. Paint has a tendency in time to crack, and, if acids are used, they will to a certain extent rot or destroy the leather; but if leather is used it will always retain both colour and texture. To choose the proper colours that will harmonise with the ground, give tone, and produce the proper effect, requires a certain amount of study. Morocco is generally used, but in Vienna calf has given very good results. If the pattern to be inlaid be very small, steel punches are used, the pattern being worked in blind on the side of the book. Take morocco of a different colour from the ground it is to decorate, pare it down as thin as possible, and lay it on a slab of lead. With a steel punch the exact facsimile of the pattern that is to be inlaid, punch out from the leather the required number of pieces. These are pasted and laid very carefully on the exact spot made by the blind tooling; press each down well into the leather either with a folding-stick or the fingers, so that it adheres properly. When dry, the book is pressed between polished plates, so that the raised pieces, or the pieces that have been laid on, may be forced well into the ground leather. When it has been pressed, the whole of the leather must be prepared as for morocco, and finished in gold. The tools in the working will hide all the edges of the various inlaid pieces, provided they are laid on exactly.

If interlacing bands are to be of various colours, the bands must be cut out. Pare the leather thin, and after working the pattern through the paper on to the leather on the side of the book, lay it on the thinly pared leather; with a very sharp and pointed knife, cut through the paper and leather together on a soft board. Or, the design may be worked or drawn on a thin board, and the various bands cut out of the board as patterns. Lay these on the thin leather and cut round them. Keep the board templates for any future use of the same patterns. The various pieces are pasted, carefully adjusted in their places, and well rubbed down. The leather is then prepared and worked off in gold.

Another method is to work the pattern in blind on the sides, pare the morocco thin, and while damp place it upon the portion of the pattern to be inlaid, and press it well with the fingers, so that the design is impressed into it. Lay the leather carefully on some soft board, and cut round the lines made visible by the pressure with a very sharp knife. When cut out, paste and lay them on the book and prepare as before, and finish in gold. This last method is not of much value, though it is sometimes chosen; for any good work, where accuracy is required, the plans mentioned previously are to be preferred.

The Viennese work their calf in the same way that the cabinet-makers inlay woodwork. With a very sharp and thin knife, they cut right through two leathers laid one on the other. The bottom one is then lifted out and replaced by the top one. By this method the one fits exactly into the other, so that, if properly done, the junctions are so neatly made that no finishing is required to cover the line where the two colours meet.

Porous.—Calf, as before described, requires more and different preparation than morocco, on account of its soft and absorbing nature. As a foundation or ground-work, paste of different degrees of strength is used, according to the work required.

Calf books have generally a morocco lettering piece of a different colour from the calf on the back for the title. This is, however, optional. Leather lettering pieces have a great tendency to peel off, especially if the book be exposed to a hot atmosphere, or if the paste has been badly made, so that it is perhaps better if the calf itself be lettered. There is no doubt that a better effect is produced in a bookcase when a good assortment of coloured lettering pieces is placed on the variously coloured

backs, and the titles can be more easily read than if they were upon light or sprinkled calf; but where wear and tear have to be studied, as in public libraries, a volume should not have any lettering pieces. All such books should be lettered on their natural ground.

For lettering pieces, take morocco of any colour, according to fancy, and having wetted it to facilitate the work, pare it down thin and evenly. Cut it to size of the space it is intended to fit, pare the edges all round, paste it, put it on the place, and rub well down. Should the book require two pieces—or one for the title, and one for the volume or contents—it is better to vary the colours. Do not allow the leather to come over on to the joint, or by the frequent opening of the boards the edge will become loose. A very good plan as a substitute for lettering pieces is to colour the calf dark brown or black, thus saving the leather at the expense of a little more time. When the lettering pieces are dry, mark the back, head and tail for the pallets or other tools with a folding-stick. Brush paste all over the back. With the handle of an old tooth-brush, rub the paste into the back. Before it has time to dry, take the overplus off with a rather hard sponge, dipped in thin paste-water. The reason why paste of full strength must be used for the back, and only paste-water for the sides, is, that through the stretching of the leather over the back in covering, the pores are more open, and consequently require more filling up to make a firm ground. Much depends upon the ground-work being properly applied.

Finishing, above all other departments, demands perfect cleanliness. A book may have the most graceful designs, the tools be worked perfectly and clearly, but be spoiled by having a dirty appearance. See that everything is clean—paste-water, size, glaire, sponges, and brushes. Do not lay any gold on until the preparation is perfectly dry, or the gold will adhere and cause a dirty yellow stain where wiped off.

Should the calf book be intended to have only a pallet alongside the bands, it is only necessary where the paste-wash is quite dry to glaire that portion which is to be gilt: this is usually done with a camel-hair brush, by laying on 2 coats. When dry, cut the gold into strips and take one up on the pallet and work it on the calf. This is what is termed "half calf neat." The band on each side is gilt, leaving the rest of the leather in its natural state. Some binders polish their backs instead of leaving them dead or dull.

Full gilt back.—(*a*) "Run-up." Make a mark up the back on both sides a little away from the joint with a folder and straight-edge. Put on lettering piece. When dry, paste and paste-wash the back. When again dry, take some of Young's patent size, melt it in a pipkin with a little water and apply it with a sponge. Lay this on very evenly with a very soft sponge, and be particular that it is perfectly clean, so that no stains be left. When this size is done with, put it on one side for future use. This size should not be taken of its full strength, and when warmed again some more water should be added to make up for evaporation. When the coat of size has dried, apply 2 coats of glaire. The first must be dry before the second is applied, and great care should be taken that the sponge does not go over the same place twice, or the previous preparations will be disturbed. It is now ready for finishing. Cut the gold to proper size; rub a little lard over the whole of the back with cotton wool. This requires great attention. Very little must be put on light or green calf, as these colours are stained very readily. Take the gold up on a cotton pad; lay it carefully down on the back; breathe on the gold, and press down again. If there be any places where the gold is broken, they must be mended. Heat a 2-line fillet so that it hisses when placed in the cooling pan or the saucer with the wet rag in it, and run it the whole length of the back on the line made before paste-washing. Do this on both sides, and rub the gold off with the gold-rag up to the line on the out-

side. Work a 2-line pallet on each side of the bands, and the morocco lettering piece last, as it requires less heat. The centre piece of each panel is next worked, firmly but quickly. The corners are worked from the centre or sides, using the right-hand corners as a guide, and judging the distance by the left-hand ones. The press must be turned when it is required to bring the left side to the right hand in working the corners. The requisite pallets are worked to finish the book head and tail, generally in one operation with the 2-line pallet.

Calf-work requires very quick working. The tools must not be held over the various places too long, or the heat will destroy the adherent properties of the albumen. With morocco this does not signify so much, as the heat is not so great.

(*b*) "Mitred back" is prepared the same way as for "run-up back," and the mitreing is done as explained in working morocco. This is superior work, requires more skill, and takes longer, but looks much better. Each panel must be an exact facsimile of the rest. If the tools do not occupy precisely similar places in each panel, the result will be very unsatisfactory. When the backs are finished, rub the gold off with the gold-rag, and clear off any residue with rubber. Be very careful that every particle of the surplus gold be cleared off, or the delicate lines of the ornaments will be obscure and ragged in appearance.

The book is now ready for lettering. Set the type up in the case, and work it carefully in a perfectly straight line over the back. The whole of the back is polished with the iron, which must be perfectly clean and bright. Prepare a board from an old calf binding, by applying some fine emery or charcoal and lard on the leather side of it. Rubbing the iron over this prepared surface will give it a bright polish. It must be used over the back by holding it lightly and giving it an oblong circular motion. Go over every portion of the back with very even pressure, so that no part may be made more glossy than another. The polishing iron should be used rather warmer than the tools: but if too hot, the glaire will turn white; if too cold, the polish will be dull. The grease upon the leather will be quite sufficient to make the polisher glide easily over the surface, but the operation must be rapidly and evenly done. All light and green calf requires less heat than any other kinds, and will turn black if the iron be in the least degree too hot.

The sides should be always in keeping with the back. Before the sides can be finished, the inside of the boards must receive attention. With a "run up" back, the edge of the leather round the end-papers is worked in blind or has a roll run round it in gold. In any case it should be paste-washed. If for blind, the roll is heated and worked round it; if for gold, it is glaired twice. The gold, cut into strips, is taken up on the roll, worked, and the overplus taken off with the rag as before directed. Extra work, such as mitred, should have some lines or other neat design put on. Paste-wash the leather, and, when dry, glaire twice. When again dry, lay on the gold all round, and work the single or other fillets, or such other tool as may be in keeping with the exterior work. When the gold has been wiped off, the leather is polished with the iron.

The outside must now be finished. If the sides are not to be polished, paste-wash the whole of the side up to the edge of the back carefully, then glaire only that portion which is to be gilt. In general a 2-line fillet only is used round the edge, so that the width of the fillet or roll must determine the width to be glaired. When glaired twice and dry, take up the gold on the fillet or roll and work it evenly and straightly round the edge. The corners where the lines meet are next stopped by working a small rosette or star on them. Clean off any gold that may be on the side, and work a small dotted or pin-head roll at the edge of the glaire. This will cover and conceal the edge.

Extra calf books generally have the sides polished. Paste-wash the sides all over, and size when dry. Hold the book, if small, in the left hand; if large, lay it on the press and work the sponge over the side in a circular direction, so that the size may be laid on evenly. Be very careful that it does not froth; should it do so, squeeze the sponge out dry, and fill it anew with fresh size. Some workmen work the sponge up and down the book, but if this be not done very evenly it produces streaks. Allow to dry by leaving the book with boards extended. When perfectly dry, glaire once. This will be found sufficient, as the size gives body to the glaire. When sizing and glairing, be sure that the book is laid down with the boards extended on a level surface; if the book be not level, the size or glaire will run down to the lowest portion of the surface and become unequally distributed.

The gold is now laid on the respective places, either broad or narrow, according to the nature of the finishing or width of the rolls. As a rule, the sides of the better class of calf books are only 3-lined round the edge and mitred in the corners. This is, however, quite a matter of taste. Some have a border of fancy rolls, but never any elaborate pattern as in morocco work. To finish the sides, place the book in the finishing press with the boards extended, so that they may rest on the press. This will afford greater facility for working the fillets, rolls, and tools necessary to complete the design on each side. The finishing press being small, it can be easily turned round as each edge of the border is finished.

To polish the sides, place the book on its side on some soft surface, such as a board covered with baize, and kept for the purpose. Use the large and heavy polishing iron, hot and clean. Work the iron quickly and firmly over the sides, first from the groove towards the foredge, and then in a contrary direction from the tail to the head by turning the volume. The oil or grease applied to the cover previous to laying on the gold will be sufficient to allow the polisher to glide easily over the surface. Polishing has the effect of smoothing down the burr formed on the leather by the gilding tools, and bringing the impressions up to the surface. The iron must be held very evenly, so that its centre may be the working portion. If held sideways, the edge of the iron will indent the leather. The heat must be sufficient to give a polish; but if the iron is too hot, it will cause the glaire to turn white. A practised finisher can generally tell the proper heat on holding the iron at some little distance from his face. Calf books should be pressed, whether polished or not.

Pressing.—Plates of japanned tin or polished horn are proper for this purpose. Put pressing tins between the book and the millboards, up to the joint. Place one of the japanned tins on the side level with the groove, turn the book and japanned tin over carefully together, so that neither shifts; lay another of the japanned tins on the top of the book, thus leaving the book between 2 tins. Put the book into the standing press, screw down tightly, and leave for some hours. When pressed sufficiently, take the book out, and if the sides are polished, varnish them.

Make a little pad of cotton wool, saturate the lower portion with varnish; rub it on a piece of waste paper to equalise the varnish, then work the pad over the side as quickly as possible, in a circular direction. Renew the wool with varnish for the other side. Enough must be taken on the pad to varnish the whole side, as the delay of renewing the varnish would cause a streaked surface. When the varnish is perfectly dry, the book is again pressed. To do this, rub the gold-rag over the sides to give them a little grease, which will prevent the sides from sticking to the polished plates. Place the book between the plates as before, leaving out the pressing tins, and put into the standing press. Only little pressure must be given; if the press is screwed down too tightly, the plates will stick to the book. The varnish must be of good quality, and

perfectly dry. Half an hour in the press will be found quite long enough. Should the plates stick, there is no other remedy than washing off the varnish with spirits of wine, and the glaire and size with warm water; then carefully re-preparing the whole surface as before. This is, however, an accident which cannot happen if due care and judgment be exercised.

Graining.—Graining is now used very much on calf books. This may be properly considered as a blind ornament. It is done by means of copper or wooden plates cut out in various patterns, so as to form small squares, scales of fish, or an imitation of morocco. Place the volume between 2 of these plates even up to the groove of the back, in the standing press; screw it tightly down. The impressions should be equal over the whole surface. Nothing looks worse than a bold impression in one place and a slight one in another, so that it is rather important that it be evenly pressed; a second application of the plates is impracticable. Graining has the advantage of hiding any finger marks that may accidentally be on the calf, and conceals any imperfections in the leather.

The state of the weather must in a great measure guide the finisher as to the number of volumes to prepare at one time. The leather should always be a little moist, or rather "fresh." In winter, double the number of books may be prepared, and the gold laid on, than the dryness of a summer's day will admit of. If books are laid on overnight, the tools must be used very hot in working them the next morning, or the gold will not adhere. During summer, flies will eat the glaire from various places while the book is lying or standing out to dry, so that constant vigilance must be kept to avoid these pests.

Russia leather is prepared in the same way as calf, but is usually worked with more blind tools than with gold, and the sides are not as a rule polished, so that the size and glaire are dispensed with, except on those parts where it is to be finished in gold; and those portions need be only paste-washed and glaired once without any size.

Finishing with Dry Preparation.—Dry preparation is used for silk, velvet, paper, or any other material that would be stained by the employment of the wet process. A number of recipes are in use.

Dry some white of egg by spreading it somewhat thickly over glass plates, preserving it from dust. It will chip off readily, when dry, if the glass has been previously very slightly oiled or greased. It must not be exposed to a greater heat than 122° F. (50° C.), or the quality of the albumen will be destroyed. The dried mass is well powdered in a porcelain mortar.

Or, take equal portions of mastic, sandrac, and arabic gums, and grind them in a mortar into an impalpable powder.

Put it into a box or bottle, and tie 3 or 4 thicknesses of fine muslin over the mouth. By tapping the inverted box, or shaking it over the lines or letters, the dust will fall through in a fine shower. The powder should fall only on the part to be gilt. Cut the gold into strips, take it upon the tool, and work it rather hot. The overplus of the powder must be brushed away when the finishing is completed.

Velvet is very seldom finished beyond having the title put on, and this should be worked in blind first and with moderately large letters, or the pile will hide them.

Silk is finished more easily, and can, if care be taken, have rather elaborate work put upon it. In such a case, the lines or tools, which must be blinded-in first, may be glaired. For this purpose, the glaire is put in a saucer or plate in the free air for a day or two, so that a certain amount of moisture may evaporate; but it must not be so stiff as to prevent the brush going freely over the stuff. Great care must be taken, or the glaire will spread and cause a stain. A thin coat of paste-water will give silk a body and keep the glaire from spreading to a certain extent; but the best medium for silk is

the dry one, as it is always ready for instant use. In using glaire, the gold is laid on the silk, but on no account must any oil or lard be rubbed on it for the temporary holding of the gold. Rub the parts intended for the gold with the finger (passed through the hair) or with a clean rag lightly oiled, and when the tools are re-impressed, use a clean piece of flannel to wipe off the superfluous gold.

Blocking has been used lately on silk with some success in Germany. The blocking plate is taken out of the press, and the gold is laid on it, and then replaced in the press. The finishing powder is freely distributed over the silk side, which is laid on the bed of the press. On pulling the lever over, the block descends and imprints the design in gold on the silk. This process may be applied to velvet, but velvet never takes the sharpness of the design on account of the pile, so that as a rule it is left in its natural state.

Vellum.—Several kinds of vellum are prepared from calf-skins: "prepared" or "artists'" vellum, with a very white artificial surface; "Oxford" vellum, the surface of which is left in its natural state; "Roman" vellum, which has a darker appearance. Parchment is an inferior animal membrane prepared from sheep-skins after the manner of vellum, and is very successfully imitated by vegetable parchment, made by immersing unsized paper for a few seconds in a bath of dilute oil of vitriol. This is used very extensively in France for wrappering the better class of literature, instead of issuing them in cloth as is the custom here.

The method of finishing vellum is altogether different from leather. On account of its very hard and compact nature, it requires no other ground or preparation than glaire for gold work.

The cover should be washed with a soft sponge and clean water, to clean off any dirt or finger marks, and to make the book look as fresh as possible. This washing must be very carefully done by going over the surface as few times as possible. This caution applies particularly to the "prepared" vellum, as each washing will take off a certain amount of the surface. It requires some experience to distinguish the flesh and leather surfaces of prepared vellum, but this experience must be acquired, because it is absolutely necessary that the leather side should be outward when the book is covered, for two reasons: the flesh side is more fibrous and adheres better to the boards than the leather side, and the leather side is less liable to have its surface disturbed in the process of washing.

When dry, the parts that are to be gilt must be glaired, and as the glaire will show its presence, or more strictly speaking leave rather a dirty mark, the tools should be worked in blind, and the glaire laid on carefully up to their outer edge. When dry, lay the gold on and work the tool in. Let the tools be only moderately warm; if too hot, they will go through to the millboard, leaving their mark as if they had been cut out with a knife.

As a rule, no very heavy tooling is put on vellum, as the beauty lies in keeping the vellum clean. As the tooling, comparatively speaking, is on the surface, owing to the thinness of the skin, it requires a very competent and clean workman to produce anything like good work on vellum.

Vellum is of so greasy a nature that, if a title-piece of leather has to be put on, it will be a matter of great difficulty to make it adhere properly, unless some special precaution be taken. The best plan is to scrape the surface, where the leather is intended to be placed, with the edge of a knife. This will produce a rough and fibrous ground on which to place the pasted leather. This leather when dry, must be prepared with paste-water and glaire, in the same manner as with other books.

Blocking. — The tools required for blocking are "blocks" or "stamps," composed of very small pieces, or in one block cut to the size of the book. In any case, the block has to be fastened to the movable plate at the bottom of the heating box of the

blocking press. To block the sides of a book, glue a stout piece of paper upon the movable plate. Then set the blocks upon one side of the book in exact position, and place that side upon the bed of the blocking press, leaving the volume hanging down in front of the press. The bed is next fixed, so that the centre of the board is exactly under and in the centre of the heating box. When quite true, the sides and back gauges are fixed by screws. Pull the lever so that a slight pressure upon the plate be given; release the press and take out the book and examine if all be correct. Some of the blocks may require a small piece of paper as a pad, so as to increase the pressure, others to be shifted a little. Now glue the back of the stamps and replace them. Put the whole under the top plate in the press, heat the box, and pull the lever over; let the book remain for some little time to set the glue. Take out the book, examine if perfectly square and correct, but replace it with a soft millboard under the stamps and pull down the press. The lever must remain over and the blocks be under pressure until the glue is hardened.

Another method is to glue upon the plate a piece of thick paper, and mark upon it the exact size of the book to be blocked. Strike the size from the centre, and from that draw any other lines that may assist in placing the blocks. Arrange the blocks upon the plate so as to form the design; when correct, paste the blocks on their backs and replace them on the plate. When the paste adheres a little, turn the plate over and put it into the press. Apply heat to the box; pull the lever over; and when the paste is set, regulate the bed and gauges.

When the press is properly heated, throw back the lever: take out the millboard from under the stamps, and regulate the degree of pressure required by the side screw under the bed. Place upon the bed the side to be stamped, hold it firmly against the guides with the left hand, and with the right draw the lever quickly to the front. This straightens the toggels and forces down the heating box, causing a sharp impression of the stamp upon the leather or other material. Throw or let the lever go back sharply and take out the book. If the block be of such a design that it must not be inverted, the whole of the covers must be blocked on one side first, and the block turned round for the other side, or the design will be upside down.

Work for blocking in gold does not require so much body or preparation as if it were gilt by hand. Morocco can be worked by merely washing the whole surface with a little urine or weak ammonia; but it is safer to use a coat of glaire and water, mixed in proportions of 1 to 3. The heat should be moderate and the working slow.

Calf should have a coat of milk and water or thin paste-water as a ground, and when dry another of glaire, both laid on evenly; but if only portions are to be gilt, such as a centre-piece, and the rest dead, the centre-piece or other design should be pencilled in with great care. The design is first slightly blocked in blind as a guide for the glairing. The edge of the glaire always leaves a dark stain. The heat required for calf is greater than for morocco, and the working must be done more quickly.

Cloth requires no preparation whatever; the glue beneath and the coloured matter in the cloth give quite enough adhesiveness, when the hot plate comes down, for the gold to adhere.

Calf Colouring.—Although coloured calf-skins may be bought almost as cheaply as "smooth" calf (uncoloured ones), yet there are many places where coloured calf cannot be procured. Skins may be purchased already sprinkled or marbled at most leather shops. This plan of sprinkling and marbling the whole skin is good enough for cheap or half-bound work, but for extra work it is far better to sprinkle, marble, or otherwise colour the leather when on the book. Hand-colouring is coming again into use, and by degrees getting known throughout the trade.

When an acid is used on leather, it is

essential to wash as much as possible of it out with water immediately after it has done its work, or in a few months the surface of the leather will be found to be eaten away and destroyed. It is a fault of some binders, that if they use a chemical on leather or paper, they are not satisfied to have weak acid, allow it to do its work slowly, and, when the proper moment has arrived, stop its further action. They frequently use the acids as strong as possible, and neglect to wash out the residue. The consequence is, the leather or paper rots. To avoid this, the recipes given below are selected for their harmless character.

Black.—Iron sulphate (copperas) is the chief ingredient in colouring calf black. Used by itself, it gives a greyish tint, but if a coat of salts of tartar or other alkali be previously used it strikes immediately a rich purple black. It can be purchased at 1*d.* per lb.

(*a*) Into 1 qt. boiling water, throw ¼ lb. iron sulphate; let it reboil, stand to settle, and bottle the clear liquid for use.

(*b*) Boil 1 qt. vinegar with a quantity of old iron nails or steel filings for a few minutes; keep in a stone jar, and use the clear liquid. This can from time to time be boiled again with fresh vinegar; an old iron pot must be kept for boiling the black.

Brown.—(*a*) Dissolve ¼ lb. salts of tartar (oxalic acid) in 2 pints boiling water, and bottle for use. This is mostly used for colouring; it has a very mellow tone, and is always used before the black when a strong or deep colour is required. It is poisonous, and must not be used too strong on the calf, or it will corrode it.

(*b*) For a plain brown dye, the green shells of walnuts may be used, broken up, mixed with water, and allowed to ferment. The liquid is strained and bottled for use. A pinch of salt thrown in will help to keep it. This does not in any way corrode the leather, and produces the best uniform tint.

Yellow.—(*a*) Picric acid dissolved in water forms one of the sharpest yellows. It must not be mixed with any alkali in a dry state, as it forms a very powerful explosive compound. It may be bottled for use.

(*b*) Into a bottle put some turmeric powder, and mix well with methylated spirit; the mixture must be shaken occasionally for a few days until the whole of the colour is extracted. This is a very warm yellow, and produces a very good shade when used after salts of tartar.

For all the following a preparation or ground of paste-water must be put on the calf, that the liquids may not sink through too much. The calf must be paste-washed all over equally, and allowed to get thoroughly dry. It will then be ready for the various methods. Perhaps to wash it overnight and let it stand till next morning will be the best and surest plan. It matters very little whether the calf is on the book or in the skin.

Sprinkles.—There are many sprinkles, all worked in the same way, by throwing the colour on finely or coarsely, as it may be wanted light or dark.

Presuming that the paste or ground-wash is thoroughly dry, take liquid salts of tartar and dilute with cold water, 1 part salts to 2 of water, in a basin; wash the calf with this liquid evenly, using a soft sponge. The calf will require the wash to be applied 2 or 3 times, until a proper and uniform tint is obtained. Each successive wash must be allowed to get thoroughly dry before the next is applied.

The next process is to sprinkle the book, with the boards open; 2 pieces of flat wood, about 3 ft. long, 4 in. wide, and ½ in. thick, will be found very useful for carrying the book. These rods must be supported at each end, so that the book may be suspended between them, with the boards resting on the rods nearly horizontally. Put into a round pan some of the copperas fluid, and into another some of the solution of oxalic acid. Use a pretty large brush for each pan, keeping each for its own fluid. The sprinkling may be commenced. The brushes being soaked in the fluids, should be beaten out, using a broomstick to

beat on before beating over the book, unless a coarse sprinkle is desired. Whilst beating over the book, the hand should be held up high, and moved about, so that a fine and equal spray may be distributed; and this should be continued until the desired depth of colour is attained.

This may be varied by putting some geometrical design, cut out of thin millboard, on the cover: or if the book is on any special subject, the subject itself put on the cover will have a very pretty effect, and may be made emblematical. A fern or other leaf for botanical work as an instance. The sprinkle must in these cases be very fine and dark for the better effect. The leaf or design, being lifted from the cover when the sprinkle is dry, will leave the ground dark sprinkle with a light brown leaf or design. "Cambridge calf" is done in this way by cutting a square panel of millboard out and laying it on the sides. The square on the cover may be left brown or may be dabbed with a sponge.

Marbles.—As the success of marbling depends upon the quickness with which it is executed, it is important that the colours, sponges, brushes, and water, should be previously disposed in order and at hand, so that either of them can be taken up instantly. Another point to which attention must be directed is the amount of colour to be thrown on, and consequently the amount that each brush should contain. If too much colour (black) is thrown on, the result will be invisible; if too little, no matter how nicely the marble is formed, it will be weak and feeble.

Marbling on leather is produced by small drops of colouring liquids, drawn (by flowing water down an inclined plane) into veins, and spread into fantastic forms resembling foliage—hence, often called "tree-marble." It requires great dexterity of hand and perfect coolness and decision, as the least hurry or want of judgment will ruin the most elaborate preparation.

To prepare the book, paste-wash it evenly all over, and, to further equalise the paste-water, pass the palm of the hand over the board after washing it. When dry, wash over with a solution of oxalic acid 2 or 3 times to get the desired tint. When dry, glaire the whole as even as possible, and to diminish the froth that the sponge may occasion, put a few drops of milk into the glaire. Again, allow it to dry thoroughly. Put some fresh copperas into a pan, and some solution of oxalic acid into another, and soak each brush in its liquid. Place the book upon the rods, the boards extending over and the book hanging between. Should it be desired to let the marble run from back to foredge, the back must be elevated a little, and the rods supporting the boards must be level from end to end. The elevation must be very slight, or the water will run off too quickly.

Place a pail of water close at hand; in it a sponge for washing off, and a bunch of birch to throw the water with. A little soda should be added to soften the water. Charge each brush well, and knock out the superfluous colour until a fine spray comes from it. A little oil put on the palm of the hand, and the brush well rubbed into it, will greatly assist the flow of colour from the brush, and prevent the black colour from frothing. Throw some water over the cover in blotches with the birch, just sufficient to make them unite and flow downwards together. Now sprinkle some black by beating the brush on a press pin, evenly and finely. When sufficient has been thrown on, beat the brown in like manner over the extended boards. When the veins are well struck into the leather, sponge the whole well with clean water. Have no fear in doing this, as it will not wash off. Then set the book up to dry.

Tree-marbles.—The cover is prepared and sprinkled in the same manner as in marbling; the boards, however, must be bent a little, and water applied by a sponge in the centre of each to give the necessary flow; when the water is thrown on, it will flow towards the centre or lowest part of the boards, and when the sprinkle is thrown on, a "tree," as it were, will be formed. The centre, being white, forms the stem, and from it

branches will be formed by the gradual flow of the streams of water as they run down.

For marbling, everything must be ready at hand before any water is thrown on, so that the water may not have time to run off before the colour is applied. The water must run at the same time that the spray is falling, or a failure will be the result.

Dabs.—This is a process with a sponge, charged with the black or the brown liquid, dabbed on the calf either all over the cover or in successive order. Give the proper preparation to the calf, and be very careful that the ground tint of brown is even. Take a sponge of an open nature, so that the grain is pleasant to the eye; fill it with black, squeeze out again, and dab it carefully over the calf. Repeat the operation with another sponge charged with brown. Cats' paw, French dab, and other variously named operations all emanate from the sponge. When done properly, this has a very good effect, and gives great relief to the eye when placed with a number of other books.

All marbles and sprinkles require practice, so that a first failure must not be regarded with discouragement. When one's hand has got into the method with 2 or 3 colours, it is astonishing how many different styles may be produced. In all this manipulation, a better effect is obtained if a yellow tint is washed over the leather after the sprinkle or marble has been produced. Again, by taking coloured calf and treating it in the same manner as white, some very pleasant effects are brought out; and when the colours are well chosen the result is very good. Take for instance a green calf and marble a tree upon it, or take a light slate colour and dab it all over with black and brown.

In all operations with copperas, care must be taken that it does not get on the clothes, as it leaves an iron stain that cannot be easily got rid of. Keep a basin for each colour, and when done with wash it out with clean water. The same with the sponges: keep them as clean as possible; have a sponge for each colour, and use it only for that colour. A piece of glass to put the sponges on will be of great use, and prevent the work-table or board from catching any of the colour. A damp book or damp paper laid on a board that has been so stained will most probably be damaged, even though it has waste paper between the work-board and book. No amount of washing will ever take away such a stain.

When the book has been coloured, the edges and inside are blacked or browned according to taste, or in keeping with the outside.

STRAW-PLAIT, MATTING, AND BASKETS.—There is so much similarity in the manufacture of these articles that they readily admit of description under a general heading.

Straw-plait.—In this industry, Tuscany holds a first place. All that which is known as Leghorn or Florence straw is raised on the hills which rise on each side of the rivers Pisa and Elsa, to the south-west of Florence. It requires a particular soil; in fact, its adaptability to the uses to which it is destined depends principally on the soil in which it is sown, which to all appearance exists only in this small district, out of the bounds of which the cultivation of straw is unknown.

The grain of several of the finest qualities of wheat, provided it be of the kind that has a hollow flexible stem, can be used for seed. The soil must be tilled and prepared very much as it is for corn, but the seed must be sown 5 times as thickly as what is usual for other purposes, either in December or February; in the latter case the crop is gathered later. When the straw is full grown, and just before the grain begins to form itself in the ear, which usually is during the months of May and June, it is uprooted and firmly tied, close to the roots, in little sheaves, each one about the size of a handful. Each little sheaf or *menata*, as it is called, is spread out in the shape of a fan to dry in the sun for 3 days, after which it is safely stowed away in barns.

After the harvest is over, and the fields are empty, it is again spread out to catch the heavy summer dews and to bleach in the sun, during which process every sheaf has to be carefully turned over every day, till it is equally white on both sides. Here the cultivator's work ends and the manufacturer's begins. But before we leave the straw-fields we must say a few words concerning the dangers to which this delicate plant is exposed during the various stages of its growth and preparation. When young and small, it is, like other crops, liable to be drowned by too much rain; or if, on the other hand, the weather be too dry, its growth will be stunted. When full grown, a storm often injures or even destroys it in a couple of hours. A whole field of straw on the eve of being uprooted will sometimes be laid down flat on the ground, and the fragile stems will be crushed, stained, and unfitted for use. Even if only slightly bent, the ends will turn upward again, and continue growing, and the little knot or joint which is then formed in the stalk renders it almost unmarketable. If the weather is only foggy or damp, the straw is exposed to rust stains; indeed, it is at all times liable to these stains if not properly dried. A great deal of wind will dry and shrivel it up, and harden it; it will also harden the ground and make it impossible to uproot the straw without spoiling it, while it will lose its flexibility and be unfit for plaiting if the grain forms itself in the ear before it is uprooted. A shower of rain will often spoil it after it has been uprooted and laid out to dry. It will be watched day and night if the weather is doubtful, and at the least approach of danger it is quickly piled up and covered with mats, or else taken under shelter. If not properly dry, it must not be kept too long piled up, or it will ferment. A great deal is often lost in that way, for as it cannot be laid out again in the wet and muddy fields, it will be spoiled, unless there are paved or gravelled places to spread it out in. When perfectly dry, its greatest dangers are over, for although watching is equally necessary during the bleaching process, changes in the weather occur less frequently and less suddenly in the more advanced season, and with a little care it is easily protected from any serious damage.

The next proceeding is the *sfilatura*, as the process of carefully drawing out each single straw from its outer covering or sheath is called. This is done by peasant girls who assemble for the purpose, and holding the sheaf firmly by the roots with one hand, they briskly pull out the straws one by one with the other, the straw thus deprived of its outward sheaf being tied in little bundles, weighed, and put aside for plaiting.

Before it is plaited, it must, however, be first properly sorted according to the different degrees of its thickness. This is usually done by machinery, the straw being ingeniously shaken in an upright position over a frame in which exceedingly small holes are bored, through which the very finest straws alone can pass. What cannot get through is taken on to a second frame with slightly larger holes, then to a third, and so on through 10 different degrees of thickness. What remains is set aside for very coarse hats and other uses.

The little bundles being now properly sorted and numbered, according to the size of the straw, the heads or ears are cut off, and the stalks are cut across in the middle to separate the top ends from the bottom, or *pedali*, the former being used for the finest plaits, the latter for the more common ones. The bundles are then wetted, and arranged in circular rows one above the other in an earthen or wooden tub or other receptacle; and a small vessel containing lighted sulphur being placed in the middle, the whole is well covered to prevent the fumes escaping, and the straw is well fumigated till it attains the proper degree of whiteness; it is then exposed to the sun until perfectly dry, and is ready for plaiting. If a part of the straw gets stained in course of preparation, it is dyed and used for mixed plaits or for coloured hats.

Nearly all the peasants plait. Some make their whole living by it, others only plait in their leisure hours, while tending cattle, or during the long winter evenings. In some places men, women, and children all plait, and little else is done. Straw merchants go about once a week in their carts from house to house, calling for the ready-made plaits, and leaving more bundles of straw to be worked. The plaits are made of different sizes and patterns, the usual plain ones being made with 7 or 11 straws, according to the width desired. An open pattern can be made by plaiting in a whalebone, which is afterwards drawn out, or the straw may be wound round a stick while plaiting, which when removed leaves a kind of curled edge on one or both sides of the plait. The plaits, if not found sufficiently white, can be again bleached and fumigated with sulphur before they are sewn into hats or bonnets ready for wear.

Straw can be sold at different periods. It is sometimes bought "on the ground" —that is, before it is uprooted—in which case a sum is fixed upon for the whole field, and the risks and costs of uprooting, drying, &c., rest with the buyer. It is more generally sold after it has been dried and taken home, and just before it is bleached, and then so much is given for each hundred sheaves, or *menate*; if sold after the *sfilatura*, that is, when cleaned and tied in bundles, it is sold by weight. The price varies according to the demand there is for it, and according to the quality of the straw. It has varied from 2 to 8 or 9 francs the 100 sheaves, so that it is impossible to give an idea of what can be gained or lost by straw raising. Machinery has lately been used for working straw, and a very pretty tissue is made of it, and used for making baskets, parasols, and other things; very pretty fanciful braids, fringes and tassels for trimmings are also made. The rich plait used for hats continues, however, to be made entirely by hand. (*Jour. Ap. Sci.*)

For centuries the manufacture of straw hats has been a special art in Tuscany, and Signa, one of the most industrious of Tuscan towns, was for a long time the centre of the trade, which, however, was of little importance and limited until the seventeenth century, when it commenced to attract considerable attention, and large quantities were manufactured both for home use and for exportation. There are 3 varieties of wheat of the golden plant (*pianta della fila d'oro*), as straw is called in Tuscany; the first is called *pontederas semone*, which produces the best straw for hats; the second, *marzuolo*, which is of a rather common quality; and the *santa fioro*, which is only used for pedals and braids. The *pontederas semone* is sown in arid soil, while the other 2 varieties require a more fertile soil. Seed is sown in November and December, according to the season, the object being to have the grain well up before the heavy frosts come, in the proportion of 11 hectolitres to each hectare, that is, about 12½ bush. to the acre. It is sown as thickly as possible, in order that the growth of the plant may be so impoverished as to produce a thin stalk, at the same time having towards the end from the last knot the lightest and longest straw. Side hills, with a gravelly soil, and high meadow lands that have had a surface ploughing and rough harrowing, are specially adapted to the straw culture, low swampy grounds being generally avoided, as dampness when the stalk is well grown renders the straw discoloured and coarse. The ground is ploughed and dug up in June, and left in this condition until November, when the soil is again turned up, and then it is ready for sowing. If the soil is very poor and thin, a very light surface of manuring is occasionally used, but this is not frequently resorted to, as it is apt to render the stalk thin and brittle. The wheat blooms at the end of May or beginning of June; it is generally pulled out by hand by the roots when the grain is half developed. For uprooting the straw, fine continued sunny weather is selected, as the rain has a very injurious effect

upon it, often turning it black. When uprooted, the branches are tied together in sheaves, each sheaf or *menata* is spread out in the shape of a fan to dry in the sun for 3–5 days, after which it is stowed away in barns. The harvest being over, and the fields being only in stubble, the straw is again spread out to catch the heavy summer dews, and to bleach in the sun for 4–5 days, but not the whole of the crop at the same time for fear of a sudden rain. Formerly the yellow colour of the straw was preferred, but now the extra white is more sought after. Before being ready to be made up into braids, hats, and ornaments, the straw has to be again bleached, fastened in small bundles, and classified. It is then cut close above the first joint from the top, and again tied up in small bundles containing about 60 stalks in each. These small sheaves are then submerged in clear water for 4 or 5 minutes, and as soon as they become partially dried, are submitted to the action of burnt sulphur (in the proportions of 1 lb. to 100 bundles of straw) for 3 or 4 nights, in rooms adapted for the purpose; during the day the doors of these rooms are left open. The classification of the straw is made according to length and colour, the ear or end of the stalk having been previously cut off; all the straw below the first knot is used simply for forage or bedding, as it is worthless for the purpose of making braids or hats.

A ready sale is found for the plait at the nearest market, though, in many instances, special contracts are made by the *fattore* (straw brokers) with the workwomen direct, they supplying the straws into which the braids are made up. Many women make 28–34 yd. of braid a day, and some can finish even 60 yd. of common braids, but fine braids require very great care and cleanliness. Owing to the great strain upon the eyes, the finer kinds of braids can only be worked upon for 2–3 hours each day; it takes, therefore, a woman 4–5 days to make braid sufficient for the hats usually worn by men, while for the superior Leghorn hats for ladies it requires 5–9 months for each hat. It is a noticeable fact that, in several districts where the finer hats are made, the workwomen suffer greatly from an affection of the eyes, caused by too close application to this kind of labour. Between 1822 and 1826, women employed in making braids realised 6*s.*–7*s.* a day, but at the present time the best braid-makers and hat-sewers only make about 1*s.* The most important centres of the straw industry are Brozzi, Signa, Prato, Fiesole, the Casentino, the Bolognese, and the Modenese. The province of Casentino is one of the most industrious in Tuscany, producing 300,000–400,000 hats yearly, all for exportation. These hats, though hitherto comparatively unknown, are now very much sought after, on account of their strength and cheapness, prices varying from 4*d.* to 1*s.* each. In the Bolognese, the straw manufacture is confined chiefly to the mountain districts along the base of the Apennines, where the inhabitants of 17 parishes are engaged in making the cheaper and coarser kinds. Laino and Scaricalasino are the centre of this trade. Bolognese hats are brought to Florence to be fashioned, and the price paid is 1*s.* 6*d.*–2*s.* 6*d.* per dozen; the quantity brought amounts to about 120,000 dozen yearly. For the last 30 years the annual exportation of straw goods from Tuscany averaged 12,000,000 *lire*, 5,000,000 *lire* alone being exported to the United States in 1878. By a comparison of the 3 principal products annually exported from Tuscany, straw goods show a value of 12,000,000 *lire*; silk, 5,000,000 *lire*, and timber, 4,000,000 *lire*. (*Jour. Soc. Arts.*)

Consul Welsh reports to the United States Government as follows:—In the city of Florence is a market for straw goods made by hand by female residents of surrounding places, such as Fiesole, Brozzi, Signa, Prato, &c. Most of the straw merchants are established at Florence, but workshops are not to be found in the city, with the exception of those for preparing, casing, and baling goods to be shipped. Ancona and Carpi are likewise places of production, but

their products are under the control of Florentine merchants.

The price of straw hats and braids depends much upon the fashion and the season of the year, winter being the marketing season; also, upon the number of straw threads used in making up, and if they are bleached or unbleached, coloured or not, &c.

Straw goods are all invoiced at the *actual market value*, they being all on consignment for sale. It is to be understood, however, that there is not a proper market in which prices for the various kinds of braids on hats are quoted, and consequently not even the local Royal Chamber of Commerce, which superintends the trade of this province, can keep any record whatever of the straw trade. The prices are subject principally to the quotations of the New York market and the importance of orders received.

It is utterly impossible to give the exact market value at which straw hats and braids are invoiced, owing to the fluctuation of prices and the difference of quotations among the various places. Moreover, the nomenclature of goods varies so much that every week merchants bring in a new name for braids and hats, which may differ but very slightly from the kinds made for years.

Goods are generally ordered by cable or letter merely by a number, each number indicating the style of straw or hat wished for—each number having a corresponding one in the sample book of the merchant. Straw braids are made in pieces and measure sometimes 45–48 meters, and in other instances 48–52 yd.

Straw braids and common or unfinished hats are baled, and the bales cost about the sum of 6*s*. Straw hats, finished, are put in cases containing several hundred dozens, the cases costing from 8–9*s*. each. Fashionable hats for ladies are carefully packed in boxes, which cost 2–3*s*.

Prior to the packing of braids and hats, they are carefully selected and folded, for which operation merchants usually charge $\frac{1}{10}d.$ per each piece of braid, or $\frac{1}{2}d.$ per dozen of hats.

Although the manufacture of straw hats was introduced into England by James I., and took root at that time in Bedfordshire, the large size of the wheat straw used for plaiting prevented the home manufacture from entering into successful competition with the finer productions of Italy.

The founders of the Society of Arts endeavoured, by the offer of rewards, to stimulate and improve the British material. The difficulty caused by the size of the straw was partly overcome by splitting it, and in 1774, a reward of 30 guineas was given to John Pepperell, for having established a manufactory of chip hats at Totnes. In 1775, 5 guineas were awarded to Robert Galloway, for the invention of tools for cutting chip hats. Ten guineas additional were given to Pepperell for the chip hats made at his manufactory at Totnes.

In 1804, the Society's gold medal was voted to William Corston for a substitution of a plait from rye straw, which he had introduced in place of Leghorn plait. Six years afterwards, Corston wrote to the Society an account of his experiments in growing the grass on Bagshot Heath and on some barren land in Norfolk, in which paper he claimed that his manufacture had then obtained an established success.

A strong interest was still felt in the improvement of the home production, as it was found that, after the re-establishment of peace in 1815, the British producers were unable to compete with the Italian straw bonnets, which were largely imported, in spite of the heavy protecting duty imposed upon them by the Government. J. Parry received the Society's silver medal for the manufacture of Leghorn plait from straw imported from Italy; and in the same year, Sophia Woodhouse, a farmer's daughter, of Weathersfield, in Connecticut (afterwards Mrs. Wells), sent to the Society an imitation Leghorn bonnet of her own manufacture, from the stems of a species of grass growing spontaneously in that part of the United

States, and popularly known by the name of "Ticklemoth." This communication met with great approval, and some of the principal dealers in such articles, after inspecting the bonnet, declared that it was superior even to Leghorn in the fineness of the material and beauty of its colour. In accordance with this expression of opinion, the large silver medal and 20 guineas were awarded to Mrs. Wells. William Cobbett was much struck with the importance of this subject, and printed an account of it in his *Register*. An importer of Italian straw then applied to Cobbett to know whether he could get any of the American straw imported. The result was that Cobbett set to work in his usual energetic manner to see if English grasses might not be used for the same purpose, and he thus opened up a fresh industry for large numbers of the unemployed, and received a large silver medal from the Society. (*Jour. Soc. Arts.*)

The manufacture of straw goods in the United States commenced in 1804, at Wrentham, Mass. The output from the New England shops is now set down at 14,000,000 hats, and from factories west of New England nearly as much more, making in all from 25,000,000 to 30,000,000 hats as the annual production of the country.

Dyeing. — As a rule, straw goods should be well steeped, and then treated with alum, orchil, and indigo extract, and yellowed with turmeric. The shades most in demand are black, brown, and grey.

Black (for 25 hats): Logwood, 4 lb. 6 oz.; bruised galls, 17¾ oz.; turmeric or fustic, 4¼ oz. Boil for 2 hours, and then steep in a beck of black liquor (crude iron acetate) at 4° or 5° B.; rinse in several waters, dry, and rub with a brush of dogs' grass, to bring up the polish.

Grey.—This shade can be obtained only on very white straws. Steep in a bath of soda crystals to which a little lime water has been added, to causticise the alkali. The purpose of this washing is to remove all traces of sulphur from the straw. For 25 hats, take: Alum, 4 lb. 6 oz.; tartaric acid, 3½ oz. Add ammoniacal cochineal and indigo extract, according to the shade desired. By making the one or the other of these wares predominate, is obtained a reflection more bluish or reddish. A little sulphuric acid is added to the beck, to neutralise the alkalinity of the ammoniacal cochineal. The hats are boiled in the dye for about an hour, and rinsed in water slightly acidified.

Maroon (25 hats): Ground sanders, 1 lb. 10 oz.; turmeric, ground, 2 lb. 3 oz.; bruised galls, 7 oz.; rasped logwood, 24¼ oz. Boil in a kettle so roomy that the hats may not be bruised. Rinse. Steep overnight in black liquor at 3° B., and rinse in several waters. To produce a deeper black, return to the first beck, which is strengthened by an addition of sanders and logwood. Polish as for black.

Havana. — This shade, being a degradation of maroon, may be obtained by the same process, reducing the proportions by ½ or ⅓, and omitting steeping in black liquor. The hats may be soaked for a night before dyeing in 4½–6½ lb. of alum. (*Mon. de Teint.*)

In order to obtain a level black colour, a solution of gluten is added to a lye of soda, which is allowed to stand for 24 hours, and filtered. The hats are then steeped for 12 hours in the clear liquid. The straw is thus freed from grease, and the mordants of nitrate, sulphate, or acetate of iron, as well as the decoction of logwood mixed with sumac or galls, is very evenly taken up by the fibre. A slight addition of potash bichromate improves the tone of the dye, and the goods are finished with gum or gelatine. (*Baden Gewerbezeit.*)

Panama Hats.—These are made from the plant *Carludovica palmata*, whose leaves are 6–14 ft. high, and 4 ft. wide. In the Isthmus of Panama the plant is called *portorico* and *jipijapa*, but the last name is the most common, and is diffused all along the coast as far as Peru and Chili; while in Ecuador a whole district derives its name from it.

The *jipijapa* is common in Panama and

Darien, especially in half shady places; but its geographical range is by no means confined to them. It is found all along the western shores of New Grenada and Ecuador; and it has been found even at Salango, where, however, it seems to reach its most southern limit, thus extending over 12 degrees of latitude from the tenth N. to the second S. The Jipijapa, or Panama hats, are principally manufactured in Veraguas and Western Panama; not all, however, known in commerce by that name are plaited in the Isthmus; by far the greater proportion is made at Manta, Monte Christi, and other parts of Ecuador. The hats are worn almost in the whole American continent and the West Indies, and would probably be equally used in Europe, did not their high price, varying from 8*s.* to 30*l.*, prevent their importation. They are distinguished from all others by consisting only of a single piece, and by their lightness and flexibility. They may be rolled up and put into the pocket without injury. In the rainy season they are apt to get black, but by washing them with soap and water, besmearing them with lime juice or any other acid, and exposing them to the sun, their whiteness is easily restored.

The process of making these hats is as follows: The "straw," previous to plaiting, has to go through several processes. The leaves are gathered before they unfold, all their ribs and coarser veins are removed, and the rest, without being separated from the base of the leaf, is reduced to shreds. After having been put in the sun for a day, and tied into a knot, the straw is immersed in boiling water until it becomes white. It is then hung up in a shady place, and subsequently bleached for 2–3 days. The straw is now ready for use, and in this state is sent to different places, especially to Peru, where the Indians manufacture from it beautiful cigar cases, which have been sometimes sold in Europe for 6*l.* apiece. The plaiting of the hats is very troublesome. It commences at the crown, and finishes at the brim. They are made on a block, which is placed upon the knees, and requires to be constantly pressed with the breast. According to their quality, more or less time is occupied in their completion; the coarser ones may be finished in 2 or 3 days, the finest take as many months. The best times for plaiting are the morning hours and the rainy season, when the air is moist; in the middle of the day and in dry, clear weather, the straw is apt to break, which, when the hat is finished, is betrayed by knots, and much diminishes the value.

Matting.—*Russian Matting.*—Mats of lime (linden) bast form in Russia the object of a considerable trade. It is no unusual thing at Riga, Archangel, and Petersburg, for English and German vessels to take in a complete cargo of them. The consumption in the country is also very large; they are made into corn sacks, coverings for cases in which goods are sent, floor mattings, corn sieves, nets in which carters carry a supply of hay, &c. On the Russian river and canal vessels, the rigging, and even the sails, are made of lime bast. Over a large extent of the country this material is used for shoes, and for roofing purposes, and in olden times it was even employed to write and paint on. In the months of May and June, when the rising sap renders it easy to peel off the bark, the peasants go out to the forest for this purpose with their wives and children. The lower part of the bark is usually employed for roofing, being first warmed and pressed so that it may not roll up; they get in this way pieces 5 ft. long and 3½ ft. wide, costing 4*d.* each. The bark from the upper part of the stem and the branches is tied up in bundles, which are laid in water, where they are allowed to macerate till September.

They are afterwards dried in artificial heat, and divided into thin fine strips, which are woven into mats of different strength, according to the various purposes for which they are to be used. They weigh 2–7 lb. each. The heaviest and strongest are sold at the market of Nischni-Novgorod, at about 95*s.* per hundred. The number of mats made an-

nually is estimated at fourteen millions, amounting in value to about 300,000*l.*

If we add to the estimate other articles made of lime bast, the total will amount to about 472,500*l.*

In order to obtain this result, about a million lime trees are felled annually, a consumption of trees which would appear to decrease the Russian forests at too rapid a rate for nature to restore the waste.

Chinese Matting.—The United States Consul at Canton reports that the manufacture of matting is extensively carried on in China, especially towards the south, where it is one of the most important industries engaged in. Enormous quantities of matting are made both for export and home use, much being used as sails on the native sailing craft, as it is cheaper, if not more durable, than the ordinary canvas or sail-cloth. It is also used as coverings for boxes and packages in which tea, sugar, cassia, &c., are exported; also in making money bags, it being a very convenient mode of handling dollars, especially when broken up into small pieces by the constant stamping or "chopping" of the dollars, as is the custom in China. The plant from which the mat sails, &c., so extensively used in China, is obtained, is known as "aquatic grass," also as "russ." It is cultivated in the Shuihing department on the West River, about 75 miles in the interior from Canton. It is grown in the same way as rice, in fields flooded with water. It requires very little care in its cultivation, as it propagates itself by shoots from the root, and attains a height of 6–8 ft. It is brought to market in bundles of about 12 in. in diameter, and if of proper length and good quality, sells at about 10*d.* per bundle, each bundle being sufficient to make 4 bed mats, or 6 such as are used for making sails. The district of Tung Kuan produces large quantities of this grass, but of a species used almost entirely in the manufacture of floor matting. It is said to grow better in the vicinity of salt water, where the water flooding it is somewhat brackish. It is planted usually in the month of June from slips. These are allowed to grow for about 2 months, when they are replanted in rows. The soil being plentifully manured with bean cake, it requires nearly 12 months to mature, when it is cut, the shoots or straws are split with a knife, and, when partially dried in the sun, packed in bundles, and manufactured into matting at the city of Tung Kuan, or brought to Canton, where there are several extensive manufactories. When brought to the factory, the grass is carefully sorted, it is then made into bundles of 2–3 in. in diameter, and placed in large earthenware jars, holding about 10 gal. of water; it is allowed to remain thus in soak for 3 days, when it is taken out and dried in the sun for a day. If it is to be dyed in the ordinary red colour, which has been for years much in vogue, it is placed in jars containing a liquid dye, made by soaking red sapan-wood chips in water. It remains in these jars for 5 days, then dried for a day, afterwards again immersed in the dye for 3 days, when it is usually ready for use. It is only within the past 2 or 3 years that other colours, such as green, yellow, and blue, have been used to any extent. The solution for colouring yellow is produced from the seeds and flowers of a plant common to China, the *hui fà*. A yellow colouring matter is also made by boiling, for several hours, 25 lb. of the dried flower-buds of *Sophora Japonica* in 100 gal. of water, and adding, when cooled, 1 lb. alum to each 10 gal. of the solution. Green and blue are produced from the twigs and leaves of the *lamyip*, or blue plant, which grows in abundance near Canton. To the solution thus produced a small quantity of chemical dye is now usually added. In dyeing these colours, the straw is soaked in water for 7 days, and then immersed in the colouring matter for a few hours only, the solution being hot. Consul Lincoln states that in a recent visit to one of the largest manufactories, he found 50 looms being worked, 8 of which were large. The large ones are exactly the same as the ordinary silk

loom, and are used in making the very wide, and also the damask or carpet patterns; 3 men are required to work each of the large looms, their wages being 1*s.* 3*d.* to 1*s.* 8*d.* a day; 8 yd. of matting from each loom is considered an average result of a day's work. The small looms are rude and simple, each being worked by 2 small boys, who are paid from 7*d.* to 10*d.* per day each, and who daily weave 5 yd. of most perfect matting of the more ordinary patterns. The loom is composed of 2 uprights, driven into the ground, about 5 ft. apart, and about 4 ft. in height, 2 cross-bars fit into sockets in the uprights, one at the top, the other about 8 in. from the ground. The warps, which are strings of Chinese hemp, 2½ yd. in length, are then passed over the upper, and round beneath the lower cross-bar, through the holes in the weaving bar, and, being drawn taut, are fastened by both ends to a long, thin piece of bamboo, placed parallel with, and just below the lower cross-bar. The weaving bar, and the most important part of the loom, consists of a piece of wood, varying in length according to the width of the matting required, and about 2 in. square; through this, small holes are pierced at different intervals, into which the warps are passed; the bar can thus be worked up and down in the warps by means of handles near the extremities—these holes vary in distance from each other according to the pattern desired—alternately on top and bottom. The holes are enlarged, or formed into slots, converging at the centre of the stick. When the warps have been thus arranged, and bundles of different coloured straw, sufficiently damp, deposited near the loom, one of the boys raises the weaving bar to the top of the warps, tipping it forward, the slits in the bar allowing the alternate warps to remain perpendicular, the holes carrying the others forward, thus separating them sufficiently to admit of a single straw being passed between them. This is done by a long flat piece of bamboo, a notch being cut near the end, into which one end of the straw is placed, and then used as a shuttle. When the bamboo is withdrawn, the weaving bar descends, carrying the straw to the bottom; the bar is then raised again and tipped down, thus carrying the warps backward which had just before been passed forward, the work of the shuttle being repeated. As the weaving bar presses the straw down, the weaver gives the ends of the straw a half-turn round the outside warps, the operation being repeated until the warps are full, the edges trimmed, the warps untied, the matting now 2 yd. in length removed, and a new set of warps put on. The matting thus woven is then dried in the sun, and over a slow fire. The shrinkage consequent on this drying is nearly 4 yd. in 40. When dried it is stretched on a frame and worked down tight by hand, then sent to the packing-house, where men are engaged in fastening the 2-yd. lengths together, it requiring 20 lengths to make the ordinary roll. The fastening together is done by taking the projecting ends of the warps of one piece, and by means of a large bamboo needle, passing them backwards and forwards through the reeds of another piece, in fact, sewing them together; each roll of 40 yd. is then carefully covered with a coarse, plain, straw mat, marked and numbered ready for shipment.

The following remarks by Dr. Hance may be taken as supplementary to the above. The plant used for sails of native craft, or for covering boxes, and described in the United States Consul's report as an "aquatic grass" or "rush," is a cyperaceous plant, known to botanists as *Lepironia mucronata*. It is recorded as a native of the Indian Archipelago, Australia, and Madagascar. Of the matting made from this plant, Dr. Hance says the natural colour is a pale brown, nor is he aware that it is ever dyed, nor, so far as he knows, is it ever exported to foreign countries, except, doubtless, in the form of bed mats for Chinese residing in Australia and California. It is certainly remarkable that a plant of comparatively

limited geographical distribution, and in none other apparently of its native localities turned to any account, should furnish the raw material for a vast manufacturing industry, and, perhaps, still more strange, that the source of this should not before have been discovered. As in the case of *Hydropyrum latifolium*, which supplies thousands of tons of a favourite vegetable, it shows how much we may have still to learn, even at the oldest and most frequented marts of trade, concerning the uses to which many apparently insignificant plants are put. The attention of the authorities in our possessions in the Straits of Malacca, and of those of Netherlands India might be advantageously directed to encouraging the cultivation of this plant, and so developing a large and profitable manufacture.

Regarding the floor matting, which forms such an important trade with America that it ranks in point of value about sixth or seventh of all articles shipped to foreign countries from Canton, the whole of this matting is woven from the culms of *Cyperus tegetiformis*. It does not seem to be known what the *hui-fa* plant is, from the flowers and seeds of which a yellow dye is prepared, but Dr. Hance is of opinion that the *lam-yip*, or blue plant, is referable to the natural order Acanthaceæ.

From a table showing the export of matting from the port of Canton from 1870 to 1877 inclusive, it seems that, next to North America, Hong Kong takes the largest quantity, Great Britain taking third. During the years as stated above the largest quantity was exported in 1872, when 115,220 rolls were sent away.

Baskets.—The subject of the periodical overflow of the Thames and other rivers should be the means of directing more attention to the possible improvement of wet ground in marshy situations by the planting of "osiers," which, under the technical name of "rods" and "willows," are a merchantable commodity, regularly in request by basket-makers, which will yield a more certain return, perhaps, than many agricultural crops that are subject to casualties arising from adverse seasons, the profit being very considerable, and the management comparatively easy and simple.

Nature, indeed, spontaneously suggests this application; for the goat-willow, or sallow (*Salix caprea*), may often be found indigenous in moist ground, more particularly in those waste and marshy situations that are, under usual practice, so difficult to deal with. A 2-year old seedling plant of the goat-willow will often produce several shoots 3–4 ft. high, and if allowed to grow longer still, and cut down every 3–4 years, no tree will produce so great a bulk of fagot wood, for a well established stock will sometimes give out in one year shoots 8–12 ft. long, straight and well proportioned, some of them 1 in. in diameter at 1 yd. from the ground. Ultimately the goat-willow becomes a fine tree, often attaining a height of 40–50 ft., with a trunk varying from 1½ to 2 ft. in diameter, and for hoops, poles, rods, crates, sheep-fences, and other purposes, the earlier produce of the goat-willow is extremely valuable.

But it is in the form of osiers regularly cropped, that can be grown upon land subject to tidal overflow, that a definite produce and consequent regular income can be relied on, and as there is a good deal of confusion existing as to the various species of *Salix*, we will briefly indicate them.

The green-leaved osier, or ornard (*Salix rubra*), is strong and tough, and in request for carboy baskets.

The Spaniard, or Spaniard rod (*Salix triandra*), has several varieties, some very good and others very inferior. The black-budded Spaniard is used for the bottoms, rims, and handles of large baskets. The grey Spaniard comes in useful for coarse brown baskets. The horse Spaniard is a very poor kind.

The old common osier, being soft, of course, and brittle, is not worth cultivating in many instances; but there are some varieties of the *Salix viminalis* that

are extremely useful, and the good and inferior ones bear such a close resemblance to each other that the difference often cannot be detected except in the working. The best variety is known under several names, as those of the snake osier, brindled osier, blotched osier, and speckled osier. The yellow-barked osier is also a good one, while the long skin is of smaller growth, but has the good qualities of being heavy, firm, and tough. The brownrod, brownard, or silver osier (*Salix hoffmanniana*), has a whitish hue on the under side of the leaf, eel baskets being usually made of this variety. The gelsler partakes somewhat of the nature of the Spaniard, but is of more tapering habit, with a thick butt. The new kind (*Salix forbyana*) is also akin to the Spaniard, being equally strong, but more pliable in working. The Hollander resembles the new kind in its qualities, but is different in appearance, and these may be seen growing in large quantities on the Dutch coast. The stone osier is a good kind, used for fine work.

The blunt-leaved ornard (*Salix lambertiana*), the bastard French (*Salix lanceolata*), and the rose ornard (*Salix helix*) are very inferior, used only for fish baskets and hampers, their ends snapping in the working inward and outward, which consequently makes inferior work; but the bitter ornard (*Salix purpurea*) grows tough and slender, and, like all the other ornards, will thrive in water.

The French, French rod, or real French has been imported from France, where it is much used in the manufacture of small ornamental baskets. On the Continent, it is much in request by wine coopers, who bind on their wooden hoops to the wine casks with it.

The rods, or willows, as they are termed in the trade, comprise several varieties, as the skit willow, the goldstone, or hornrod, of which there are 2 subdivisions—the wire hornrod, which is thin and tough, and the water hornrod, which is very inferior. The rods (osiers, &c.) grow best on strong and loamy soils.

And here we should remark that soil exercises as material an influence upon the growth of osiers as upon other crops. They require a compact subsoil that retains moisture, and thus they will not answer in strong clay soils, which in summer become hard and dry; for these crack, and the moisture of the land evaporates. The Spaniard, new kind, and French sometimes answer very well upon light land, where the subsoil is kept moist by land springs; but where the supply of moisture is imperfect, an osier plantation lasts a comparatively much shorter time, and requires renewing in 15–20 years; but in land the best adapted for their growth, by the margins of rivers subject to tidal overflow, they will last for fully 70 years with occasional mending. On light land, the osiers are smaller and shorter, and the crop is less bulky than when grown upon strong loam.

Upon the first formation of an osier plantation, the ground should be well trenched to the depth of 1½ ft., and in light soil the sets should be planted in rows 18 in. apart and 15 in. from each other in the row; for where the supply of moisture is not continuous, the shoots are fewer and shorter, and it is in such situations that the smaller varieties suited for the manufacture of small baskets are grown; and there is an advantage in thus planting them close, for if more space were allowed, instead of drawing each other up long and slender, they would branch out and grow crooked and "clubby" near the stools.

Upon soil better adapted for their growth, which is rich and continuously moist, they are planted at wider intervals, for upon such they will reach a length of 8–12 ft., so that the rows should be placed 2 ft. asunder, and the sets stand 1½ ft. apart in the rows. If these were planted as close as the former, the result would be that, there not being room enough for the number of shoots that the stronger plants will throw out, a few of the leading ones would get very tall, and their growth would prevent the action of light acting upon the others, which in consequence

would become of inferior quality and not ripen their wood in the course of the season, which in this state would be soft and pithy, and consequently unfit for manufacturing purposes.

The action of light upon osiers is somewhat remarkable. In ordinary seasons they are of a yellowish brown, but they sometimes assume a dull green colour. The willows in cloudy seasons are of a dull brown mahogany colour, but in clear seasons the shoots grow of a bright red colour.

The sets are cut from the lower part of the shoots, and are generally used about the thickness of one's little finger for the larger varieties. The small part of the rods would strike just as quickly, but they produce smaller shoots. The sets should be about 16 in. long, and be inserted into the ground at about half their length.

In severe seasons some of the plants will die, the most injurious weather to an osier plantation being when mild winters are succeeded by hard frost in early spring. The plantations will then require "mending," which is done in the following manner: The longest and smoothest rods are chosen, which are cut from their butt ends in a slanting direction, and are thrust into the ground by the side of the dead stool, to a depth of 8–9 in. These are inserted as they have grown, without being shortened, for if this were done they would be smothered by the shoots of the older stools, and by being inserted of their full length, they have the benefit of air and light for a considerable time, which enables them to establish themselves before the others grow high enough to overtake them, when the summer will be considerably advanced.

Osiers may also be grown upon springy land that is sometimes met with near the bottoms of elevations, the slopes of which are kept moist by the drainage of higher lands; and although such springs might often be cut off and drained by means of a few deep drains, aided by auger holes driven down into the porous watery strata which form their reservoirs, by the method known as the Elkington system, after the name of the farmer who first practised it, such drainage is very often left undone; and there are many waste spots upon which osiers could be profitably cultivated, which would prove a source of profit to owners or occupiers of land, that are frequently entirely neglected and overlooked.

Osiers can be cut any time between the fall of the leaf and the rising of the sap in the spring. And although they are often cut before and after this time, it is not good practice to do so, especially when cut late in the spring, as it weakens the succeeding crop.

According to the accounts which have been published, the osier grounds upon the estate of Holkham, that are planted with *Salix viminalis*, commence their profitable return the second year after their formation, the first crop averaging 34*l.* 17*s.* per acre, after which they are cut down yearly and realise about 27*l.* 10*s.* per acre.

The principal obstacle to general cultivation of the osier is the labour of peeling it, a work that must be performed at or near the locality of its growth. The shoots are cut after the ground is frozen, to prevent the roots from being pulled from the soil in the act of cutting. They are bound in large bundles and placed in a tank, or on a level piece of ground, supported in an upright position, and water to the depth of 2–3 in. is allowed to flow over the butts. After standing until spring, the stem has absorbed water enough, by capillary attraction, to render the removal of the bark easy. This is done by drawing the shoots through a split sapling or between 2 upright pieces of iron. This is a labour of patience, and cannot be slovenly performed. Although machines have been devised for the work, they have not proved entirely satisfactory, though a passage between brushing rollers ought to be effective.

Varnish for Baskets.—(*a*) Good linseed oil is boiled in a capacious vessel until a drop of it when poured upon a cold stone slab becomes so viscid that it strongly adheres to the finger when

touched, and can be drawn out in long threads. This is mixed with 20 times the quantity of good, fat copal varnish, and the varnish is reduced with as much turpentine oil as is required to bring it to the desired consistency. To colour this varnish if required, it is best to add aniline colours dissolved in benzol, and to mix the solution intimately with the varnish.

(*b*) Mix 1 oz. shellac and 3 oz. rosin with 1 pint naphtha; shake till well dissolved, and allow to settle before use.

MUSICAL INSTRUMENTS. —The construction and repairing of musical instruments in general favour, such as pianos, harmoniums, and violins, form a fitting subject for the present volume.

Pianos. *Selecting.* — The chief points to be considered in the selection of a piano are its durability, tone, and touch. As to appearance, the buyer will please himself; but in the workmanship of the case much may be found that will help to decide its character. There is a saying that "the outside is of no consequence if the inside is good"; but a good piano is rarely put in a bad case: it will therefore be as well to notice closely the outside finish, and if any sign of rough work is perceived, not to risk becoming its possessor. It need not be very elaborate, for a cheap piano covered with carving and of flashy appearance is to be mistrusted. But, however plain it is, such work as there is should be good, and bad joints filled with cement and glazed over with polish may be taken as a sure indication of like defects in the more important parts of the interior. At the same time, there is no reason why the eye should not be pleased as well as the ear, so that there is no need to go to the other extreme of supposing that it is only the ugly which is necessarily good, for such ornaments as perforated panels, carved cabriole legs, and mouldings are now turned out so cheaply as to form only a very small item in the proportionate cost.

With regard to the important qualification of durability, it is impossible for any but the maker to pass any opinion. The buyer had better, therefore, place himself entirely in his hands, but in the matter of tone he ought to be able to discriminate. Sweetness must not be entirely sacrificed to power, for if the tone is what is termed "brilliant" when new, it will speedily degenerate into harshness as the hammers harden by wear. A pleasing mellow tone, with well-sustained vibration, is that which wears the best, and will eventually develop into volume, which is the quality most to be desired.

The next item, and one claiming serious attention, is the "touch," for on this depends in a great measure the pleasure and comfort of the performer. It is to be understood that at present the plain "hopper" action only is under consideration, which, for hard work and simplicity of movement, is perhaps to be preferred. The depth of the touch should not exceed $\frac{5}{16}$ in. to a hammer motion or "blow" of 2 in. These distances are often increased, since by so doing the hammer acquires greater momentum, and consequently brings out more tone. But as this is at the cost of augmented friction, the wear of the parts is greatly accelerated. The cutting of the hoppers and their respective checks may now be examined. To test the accuracy of the first, notice that there be no play between the top of the hopper (which, it will be seen, is blackleaded and burnished to reduce friction) and the lever immediately above. To prove the checks, press down quietly a few consecutive keys, and carefully watch the motion of the hammers. These should barely touch the strings, and then fall (in a line) about $\frac{5}{8}$ in. from them. Particularly note, during this operation, that there requires no increase of pressure, as the hammers approach the strings, for this would indicate that the "stickers" were hinge-bound, the effect of a hard, inelastic quality of hinge leather. In pianos of a low price this fault is not uncommon, and its effects on the fingers of the performer are most unpleasant. It may be said that this will disappear with playing, and no doubt it sometimes does, but there are instances where it

has been just as bad after many years' use, and the only remedy was found to be an entirely new set of hinges, so that it will be advisable to have it corrected before purchase.

Finally, the method of stringing is worthy of consideration. In instruments of the class under notice, a bichord is preferable, unless it may be for about one octave in the treble, principally because the tension and consequent fear of collapse is then at a minimum. Neither perhaps, though generally so supposed, is a trichord any improvement to the tone. At first sight it may appear unreasonable to doubt this, but it must not be forgotten that though there is an extra string to sound, yet owing to the further division of the blow each string is struck with less force. The effect, also, of extra weight on the vibration of the sound-board must not be underrated. In actual practice it has been found that, other conditions being equal, a bichord has an equal volume, and possesses a purer quality of tone, with longer vibration, while—and this is certainly of some consequence—it is easier and less costly to tune.

Putting in a String.—Some time before the mechanism of a piano begins to show signs of being the worse for wear, and often even when comparatively new, such contingencies as broken wires and hinges are more familiar than pleasant, and are generally evidenced by one or more of the notes becoming dumb at most inconvenient times. The former are by far the more common, and are at the same time much the easier to remedy. To be the better prepared for such casualties, it is well to provide a cheap tuning hammer, such as may be bought for 1s., and a few of the treble sizes of steel wire, also a small quantity of fawn leather and parchment for the hinges, the whole costing about 3s.

To put on a string, the action must be removed, and the broken wire taken out. Even if nothing more be done, this will be a great gain, as the string will generally lie across others, causing the whole to jar. The size of the wire (music gauge) is ascertained by reference to the number written upon the plank at the treble side of the string. In most pianos it will be found that the wire passes round the hitch-pin again to the plank. By this plan, the eye at the bottom is dispensed with. Where an eye is necessary, it will be easier to make what is called a French eye. This is done by bending the wire into a loop and turning the loop end twice round just above. This end is then bent at right angles and cut off about ¼ in. from the twist, which will prevent its running back. The top end is wound in close coils round the wrest-pin, this being hammered down to its proper level before tightening. The wire is put in its position on the bridges and tuned roughly between its two outside notes, when the action can be replaced, and the tuning finished from its octave below. In pianos where the treble notes are not of good quality, or where the strings are continually breaking, considerable improvement will be effected by renewing the top octave, the increased brilliancy obtained by this means well repaying the trouble taken.

Repairing Sticker-hinge.—To repair a broken sticker hinge, unscrew the button from the damper wire. The sticker can then be separated from the lever to which it is glued, and removed from the action. The old hinge is then picked from the slot and from the hammer butt. For the new hinge cut a piece of fawn leather rather larger than the finished size. Hammer it to a sharp bend at the middle, which just touch with thin glue and press into the slot with a blunt table-knife. The hinge is then trimmed to its proper size, and the damper wire passed through its socket. In glueing to its place, avoid being too liberal with the glue.

Re-hinging Levers.—To re-hinge a lever, damper, or hopper: One portion of either of the two first will be found adhering to its rail. This must be detached with sufficient care to avoid tearing the wood; a hot iron then applied to the part immediately above the broken hinge will destroy the old glue, and permit the groove to be sprung

open (not entirely separated), so that the parchment may be removed, and a new piece inserted. The joints are then pressed close with a small screw or tied round with thread until the glue is set, any superfluous glue being previously removed from the hinge.

Centres sticking. — Centres sticking nearly always arises from damp, but with the exception of the keys, is happily not of common occurrence. When it happens with the hammer centres, the only permanent cure, other than removal to drier premises, consists in taking the entire action to pieces, and broaching the centre cloths; but this is so difficult of execution that few, even practical hands, would care to undertake it. When a heavier touch is not objected to, a remedy has often been found in glueing small pieces of weighted pine at the back of the stickers, sets of which are sold expressly for this purpose.

Keys sticking.—Keys sticking are remedied by slightly easing the front hole with a small flat file, care being taken to remove only sufficient wood to take away the pin mark. To test if the key also binds in the centre, lay the key so that the centre pin just enters the countersink of the round hole, when its own weight should be sufficient to cause it to sink to its proper position. If it does not do so, the centre square hole also requires easing; the round hole rarely needs altering. Keys will also occasionally stay down where, in consequence of the frame warping, the front pin is out of the hole. This can be detected by the mark; where, on the contrary, through hard service, the keys have become loose, and rattle, a new and larger set of pins may be substituted. This will be found quite as easy to do, and a much more effectual remedy than wedging the holes.

Blocking.—Blocking is caused by the hoppers not "setting off." The effect of this is most unpleasant, as the hammers then block or jam against the strings, and deaden all vibration. The regulating wire in the hopper should be unscrewed about half a turn, so that the hopper slips from under the lever just as the hammer reaches the strings. Where the blocking is accompanied with a creaking noise on the keys being pressed down, it is the effect of damp, and on examination it will be seen that the top of each hopper has become rough through the softening and consequent abrasion of the blacklead (graphite). A little of this applied damp with a small leather pad, and afterwards burnished with a piece of smooth steel (such as the barrel of a tuning hammer), will put matters right. Where the blocking occurs from the check of the hopper, the touch is too deep for the blow, and a piece of brown paper should be put under the baize at the front of the keys.

Moths.—Of all the ills to which a piano is liable, the effects of moths and moisture are the most disastrous. Of the two, the former is perhaps the more destructive, because the attacks are more insidious, and the mischief is generally very far advanced before it is discovered. There is no part of the action, however small may be the aperture, that will escape the ravages of the grub, and many a fine instrument has in a short time been converted by them into a complete wreck, and even after a thorough repair and supposed complete extermination of these pests, the destruction will often recommence; so that wherever there seems reason to suspect their existence, the most rigorous examination and cleaning of all parts of the interior is imperative. A saturation also of the suspected parts with spirit and camphor has often been found productive of good effect.

Damp.—To guard against damp, it is advisable that a piano should never be placed, if it can be avoided, on a stone floor or close against an outside wall. Where this is impossible, it is better to raise it either on a thin wooden partition or on "insulating" glasses, so as to allow a passage of air all round; also occasionally removing the front, and where the hammers seem inclined to stick, place the action at a little distance from the kitchen fire. Other symptoms of damp,

and the way to cure them, will be noticed farther on.

Durability.—Pianos that have been made within the past 20 years or so are, both in frame and mechanism, of much greater durability than those of earlier date. In the latter, among other shortcomings, the action centres were so tender, even when comparatively new, as to require the greatest care in handling; whereas, in the more modern instrument to effect a casualty would take an amount of force not likely to be exercised, so that with common care the different parts may be taken asunder without the slightest risk. As a rule, the public are slow to appreciate this, and the old fear of meddling with any portion of the interior still exists. With the harp, on the contrary, one of the first lessons a purchaser finds it necessary to learn is to tune it, and replace broken strings, and it would be considered quite exceptional, even for a lady, not to possess this amount of skill. It may fairly be urged that as the tuning of a harp is diatonic, and the strings so much more accessible, there is little comparison between the two; but it must also be remembered that though the tuning of a piano, as a whole, may be, and generally is, beyond the powers of an amateur to accomplish, there are yet many accidents to which the mechanism is liable, which, though trivial in themselves, are not on that account the less annoying (especially when it happens, as is often the case, where the visits of a professional tuner are few and far between), and yet are very easily put right—such an occurrence, for instance, as a crumb or other small article getting between the keys will occasionally render a piano useless, and necessitate, besides delay, the expense of a tuning, when probably it would not otherwise require it. How often the simple breaking of a wire has a like effect most readers know to their cost.

Taking to pieces.—In upright pianos the whole of the movable parts are kept in their places by what are termed steady pins, so that when replaced they are certain to be in their exact position for playing, and as the first step in repairing is to obtain access to the interior, the beginner should accustom himself to take all these to pieces until he is familiar with the mechanism. To take out the doors, having turned back the buttons (if any), pull them forward at the top, and then lift them up off their bottom dowels — in replacing, these movements are reversed—the cylinder and hollow can then be lifted out, the left hand holding the cylinder, and the right placed under the back of the hollow. The action is removed by pulling it forward at the top, and lifting out by the hammer-rest; where the dampers are detached it will be easier if they are first taken out. In replacing, it is necessary to be careful in guiding the back of the action over the hoppers, and in placing the dowels at the bottom of each standard in their respective holes, when, by a slight pressure at the top, the action will slip into its place. In pianos that are fitted with a double check action, the *modus operandi*, though still the same, is a little more difficult of execution, in consequence of both the weight of the action and the complication of its parts, but generally in such instruments special directions are pasted inside to serve as a certain guide. Keys may be taken out by lifting them at the front until they are clear of the centre pin, when they may be drawn forward. In practising these movements, it must be borne in mind that under no conditions should force be exercised, as every part should drop easily into its place.

Keys.—Lime-wood is generally used for keys, though any straight-grained and tough wood would answer quite as well. When the middle of a wide board is used, the keys at that part are liable to warp, and sometimes to twist. A slight warping may easily be cured by laying the hollow side of the key on a flat-iron, and gently striking the upper side with a broad-faced hammer, between the centre hole and the hopper, the key being bent, by a pressure of the hand, in the direction required. If the warping is very bad, it will be necessary to

wedge saw kerfs about ¼ in. deep in the hollow side, though this requires great care, as the key is apt to break. A twisted key is very hard to straighten, as the saw kerf will have to be diagonal, and a wrong slant will only make it worse. A great deal can, however, be done with the plane, and by resetting the hopper or by bending the key pin. Pine makes a very good key, when slipped at the pin-holes with a hard wood.

Hammers sticking.—In all problems relating to the repair of pianos, it is not so much the cure as the cause of a defect that is difficult to discover, for when the latter is once known, the remedy is generally easy enough. Properly speaking, a hammer can only stick from its centre; but a damper wire out of place or binding in its socket, a hinge-bound sticker, or a broken tape to a check action may each be described as a "sticking hammer," although the hammer itself may be perfectly free. It is so common to see a set of centres completely ruined by unnecessary broaching that it is worth while taking some trouble to first ascertain whether the centre is too tight or not. It is pretty good evidence that the sticking is caused by the damper wires when the hammers are free at the treble end, but this will be rendered more conclusive by bending one of the wires out of its socket and trying the effect. If the hammer is then free, it is the socket rail which must be broached; but if the hammer still sticks, it must be either that its centre is tight, or the butt of the hammer is jammed between the forks of the rail. To test for the latter, insert the point of a pen-blade between the fork and butt, and whilst there work the hammer to and fro with the finger. Should this not succeed, there is nothing for it but removing the wire and broaching the centres; but this is altogether too difficult a task for any amateur to attempt. Dampers are often kept from the strings by hanging upon their lifts. If upon the damper wire lift, screw down the lift (or button) until there is the space of a card between the lift and damper. With Collard or Kirkman dampers, they may also hang upon the rail lift, or the piece of wood which lifts the dampers when the loud pedal is down. Either of these makes may be eased by enlarging the screw holes and lowering the lift, though for Broadwood or French dampers this is not needed.

Pitch.—It is useless to keep tuning up to pitch, until the cause of giving way is remedied. The causes are various. If the wrest plank has not been thoroughly seasoned, it would cause the pins to give from the immense strain on them. The same remark may be applied to that part (at the bottom of the piano) where the hitch pins are inserted. Instances have occurred where the hitch pins have been torn through the wood from the strain on them. If the scale or speaking length of string between the belly bridge and wrest plank is not to the correct length, it will cause a breakage of the strings, and the instrument cannot be kept up to the standard pitch. A good many pianos become worthless from the inaccuracy of their scale. Now for the remedies: To cure looseness of the wrest pin in the hole, if the wrest plank be sound, put a larger wrest pin in. When the hitch pin does not hold in the bent side or bottom block, if the bent side or bottom block is sound, replace either with a stouter or longer hitch pin. (W. H. Davies.)

Buzzing.—"Buzz" is the most important of the minor defects of a piano, as it is generally also the most persistent. The conditions under which it may occur are various, and for the most part, simple and easily removed:—

(*a*) Shavings may have been left in the bottom of the case or at the lower ends of the wires, and will be seen on removing the lower panel, i. e. the one below the key-board.

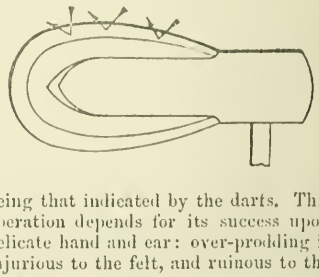
(*b*) The cause may be found in a loose fit of the upper or lower panel, or of the fall, or of the bar upon which the fall rests, or of the lining under the key-board; or the fall may not truly lie back when opened, or the lid may not rest evenly upon the sides and front. Any defect in the fitting is sufficient to cause a buzz.

To discover the cause: first raise the lid. If the buzz ceases, the cause lies in the fitting of the lid, which must be adjusted by raising or lowering one, or both, of the hinges at the back. If not, remove the upper panel. If the buzz ceases then, find out what part of the front causes it. The panel being replaced, the buzz will probably again be heard: it may happen that by merely taking out the panel and putting it in again the defect in the fit has been remedied. If not, the part whose looseness causes the buzz, will be found by pressing the panel in its frame, or the frame itself downwards, inwards, outwards, or sideways, until the disagreeable noise ceases. It is possible that a piece of ordinary writing paper gummed or glued on at the spot, where pressure has stopped the buzz, will be sufficiently thick to produce a perfect fit. If the manipulation of the front does not bring about the desired result, proceed in the same manner with the lower panel, the key-board lining the fall, and the bar on which the fall rests. The fall is removed by simply raising it: if the fit is perfect, this is not easily removed. The bar beneath is fixed by a sunk screw at each end to the frame of the piano. The key-board lining is usually sprung into position, wedging itself into the slits which receive it, and the defect will be an imperfection of the wedging. A thin slip-wedge is the remedy.

(*c*) Torsion of the sound-board may arise from the woodwork adjoining the iron studs which, when the lower panel is removed, are visible at the base of the piano, projecting through the sound-board. This is originally cut away just enough to admit the passage of the studs without contact. These studs, however, have a very sharp rise, and it may happen that the tension of the strings produces in the lower part of the board a certain amount of torsion, and very little suffices to bring the two into contact. When this takes place, a buzz results. The remedy is obvious, by means of a thin narrow sharp knife.

(*d*) Great difference is to be noticed in the tone of different pianofortes, and even of different notes on the same piano. These differences are largely dependent upon the material of the frame and bridging; and it may be said broadly that *cæteris paribus*, the tone will vary between sharpness and shortness, and softness and rotundity, according as metal or wood predominates. But quite distinct from these qualities, accidental to the material, is the clearness of note given by a perfect instrument, the result of effective toning. The operation is simple, but delicate in the extreme, and the affected part is the felt covering the hammers. This felt, which is of a very fine kind, varies occasionally in density, and this variation may sometimes produce a buzz. An operation which improves the quality of the tone, and removes the buzz (when attributable to the cause under consideration) by equalising the density, consists in pricking the felt on the upper part of the hammer with the toning tool, which, in its simple form, is a fine steel fork of 3 short sharp prongs. The felt is not perpendicularly prodded, but the points of the fork are stuck into the felt as often as is requisite to produce the correct tone, and in the direction shown in Fig. 190, the motion

FIG. 190.



being that indicated by the darts. This operation depends for its success upon delicate hand and ear: over-prodding is injurious to the felt, and ruinous to the tone.

If the buzz does not yield to one or other of the remedies indicated, the cause will probably be insufficient tightening of leading screws, or defective fixing of the foundations, or imperfect glueing, and the instrument must be handed over to a pianoforte-maker.

Faulty repetition.—Another common defect is in the "repetition": a key will not rise to the level instantly the finger is raised, it rises either slowly or not at all. This may result from one of two causes; either the key has warped or it has swollen.

(*a*) The warping of the key will probably be the result of the piano having been subjected to extremes of temperature—great heat in summer, and great cold in winter; or perhaps one day the room is without warmth of any kind, the next it has a roaring fire. In time the keys will stick. To remedy this, raise the lid and remove the front, the fall and the bar, raise the key by the forepart, above the pins which keep it in position, and draw it forwards. Where the key rubs its neighbour, it will generally appear chafed, but if no chafing is apparent, just rub the side lightly with blacklead, and replace the key—it will now blacken its neighbour at the point of contact, and at the corresponding part of itself it may be rubbed down very slightly with glass-paper, first No. 1 then No. 0.

(*b*) Swelling of the key is the result of damp alone, which operates by decreasing the size of the holes into which the fixed pins fit, and these are accordingly more or less gripped by the key. Perhaps only one is tightened, more likely both. On taking the key out, it will be at once apparent whether both pins are gripped or only one, as the piece of cloth in the forward hole, and the wood itself in the case of the other, are dented and blackened. The hole may be enlarged to the necessary extent by shaving the wood with a fine penknife, but preferably by filing it with a fine fret-file of oblong section. No more should be taken off than is just sufficient to enable the key to work freely, as otherwise the key will rattle and work unevenly.

There are some external causes of "buzzing" which demand attention. Thus the piano may be standing on a loose floor-board: the remedy is to fasten the board tightly with screws, removing the loose nails, or hammering them well in. Glass in pictures, mirrors, windows, doors, &c., may be loose or cracked; also gaselier globes and candle chimneys. The remedies are tightening or placing a piece of cloth between the glass and its support. China ornaments, for a similar reason, should rest on or against a deadening material. The scuttle, fender, and fire-irons also require looking after to prevent jarring. Nothing should rest on a piano while it is being played. If candlesticks are necessary, their feet should have baize glued on, or they should stand on mats.

Renewing Pins and Wires.—As the pins and wires of pianos become worn, it is necessary to renew them. First remove the action—the apparatus which sets in motion and includes the hammers. Raise the lid, take out the front by undoing the little button at each end of the top, drawing it outwards at the top, and lifting it from the pins in the upper edge of the fall. Then remove the fall, and the action is fully exposed. Before removing it, observe whether the dampers do or do not form part of the action. If the wire which passes up between the "stickers" (upright rods which set the hammers in motion) goes through the head of the damper and is secured at the other side by a nut, and if the dampers have no independent frame working in its own sockets, as may be known by moving the right pedal, the dampers cannot be taken out separately. Those having such a frame will work in a socket at each end, or a socket at one end and an eyelet-hole on a screw at the other. Turn the buttons and lift up; or turn one button, raise that end, and draw out of the eye.

Fixed to the inside of each end, and 6–8 in. from the top, is a block carrying a button, which keeps in position the upright bars forming the ends of the action frame. Turn these buttons, draw the upper part of the frame outwards, and then lift upwards and outwards bodily. The action is a delicate part, and at the same time heavy, and to remove it without an accident requires firmness and carefulness to exercise

equal strength at each end. The slip lying across the keys will be removed by unscrewing at each end, and the keys can then be raised. The keys are all numbered, and it will save much time in replacing if they are put aside in an orderly way.

To substitute new or replace the old pins, the piano should be laid on its back, and this may as well now be done. The pins are slightly roughed on the part which lies in the head-piece; as this roughness is screw-like, there will be but little difficulty in extracting them. To remove a pin, first turn it sufficiently to relax the string. This can most conveniently be done with a tuning key, but a strong pair of ordinary pincers may be made to serve. When turned enough, remove the string, and then extract the pin with the pincers, turning to the left and drawing out.

It is possible the old pins will do with a little help, in case it is not easy to obtain new and larger ones. Take out one of those belonging to each note of an octave in the most-used section of the instrument. Thoroughly dust the sides of the holes with dry finely-powdered chalk, replace the pin, and hammer it well in to the proper extent, i.e. up to the head or blackened portion. The great points in repinning are to drive the pin in perfectly perpendicularly to the head-piece, and to drive it well home. The little hole in the pin should be perpendicular to the base line of the piano. As it is of paramount importance that the pin should fit very tightly, it will require the exhibition of not a little well-directed strength to do this properly, but there is nothing really difficult in it.

The removal of *one* pin to a note will be quite sufficient in the case of a trichord or semi-trichord piano; but care must be taken to remove corresponding pins in adjacent notes by which is meant the pins bearing the ends of one string. Thus in Fig. 191, which sufficiently shows the system of stringing, the pins marked represent those to be removed. In a bichord, both pins must be removed, as the one string furnishes the 2 chords. If the chalk answers its purpose, the string kept by the pins thus treated will remain in tune while the other strings are affected. The difference will first become sensible by a vibration being audible on the one note, and the remedy will be proved by the difference in pitch on damping the wires in succession, and striking the note if the difference between the number of vibrations of each string is sufficient to be separately appreciable.

In the illustration, *a* is a monochord double-covered string; *b*, a bichord single-covered string; *c*, a bichord plain wire; *d*, a trichord plain wire.

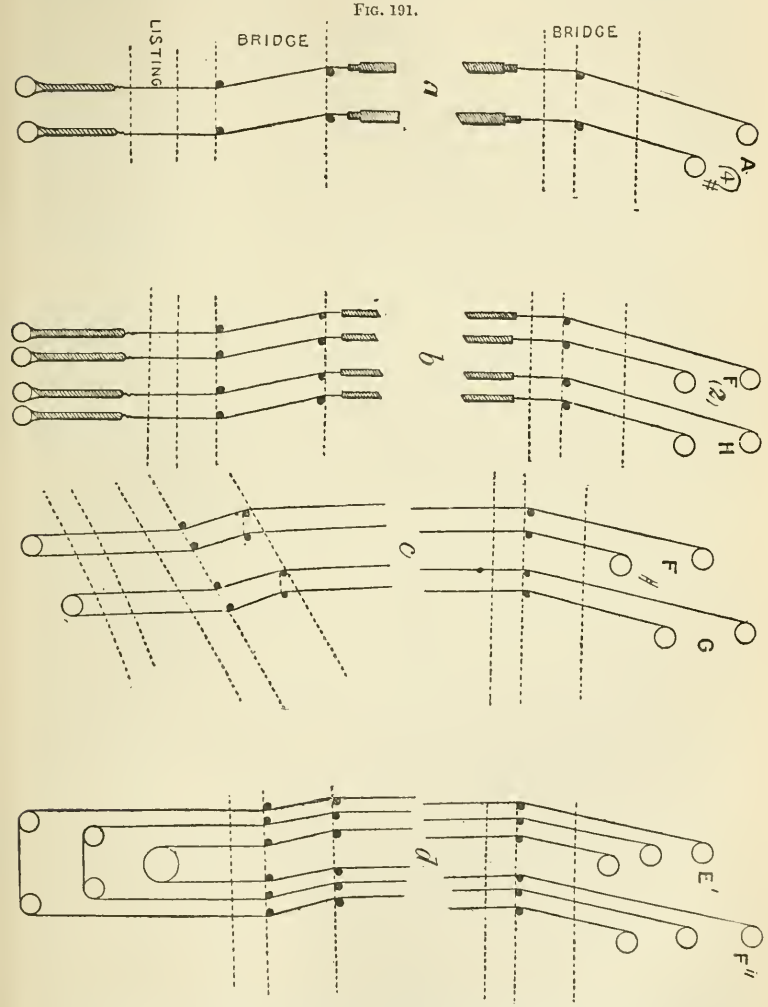
Pins are made in 6 sizes. Hughes, 37 Drury Lane, sells complete sets of the ordinary size ("02 A") at 1*s.* 8*d.*; and of the largest size ("0000 A") at 2*s.* 6*d.*; for numbers less than a set, 4*d.* per dozen.

The pins being fixed, put in the wires. Of these there are 3 kinds: double covered, single covered, and plain; the first-named being for the lowest bass notes. All the covered ones are fixed singly; each chord is a separate string. The plain ones are fixed one to a note in a bichord, or the bichord portion, and 3 to 2 notes in a trichord. The course of the strings in each case is shown in Fig. 191. Care must be taken that the wires properly traverse the bridges, and are caught by the right pins, which are intended to shut off the part not intended to vibrate from the free part on which the hammers act. The wire is then drawn through the little holes in the wrest pins as taut as possible (a sufficient length in the case of the plain wire being cut off the roll), and given a turn to secure it from slipping. It is then tightened up with the key, and finally tuned. It will have been noticed that below and above the bridges are pieces of braid, flannel, or listing running in and out of the wires. These are very necessary, and serve to deaden the part of the wires beyond the bridges. Just below the line of wrest pins should be figures to indicate the size of the wire used; for all notes between any

2 of these numbers, the size indicated by the lower is to be employed.

2*s.* 6*d.*, whether plain steel or covered. The latter kind is also sold by the single

FIG. 191.



The wire, in bulk, is sold by the pound, for which weight the price is string, from 4*d.* for the thinnest to 1*s.* for the double covered.

Rusty Wires.—Wires are frequently found to accumulate rust. This arises solely from damp, either a damp atmosphere in the room generally, or damp ascending from the floor. The latter may be checked by covering the floor beneath the piano with a sheet of waterproof paper, either Willesden paper or ordinary brown paper well dried and coated with linseed oil varnish on both sides, laying it under the carpet.

To remove rust from the wires, rub them lengthwise with a piece of fine chamois ("shammy") leather with emery flour or crocus powder spread on it, thoroughly removing every particle of the powder afterwards with a clean leather.

Celeste Pedal.—To soften the tone of a piano, use is made of a pedal action which shifts the hammers so that they strike less wires—1 instead of 2 in the bichord, and 2 instead of 3 in the trichord. By the Celeste method, the hammers strike always the same number of wires, but the softening effect is gained by interposing a layer of felt between the hammer and the wire.

On taking away the upper and lower panels and the action frame, and supposing the remaining fixed part and the right pedal lever removed, there are only the back, body, strings, and soft pedal lever left. At the back of the action frame runs a strong board, which keeps the stickers and hammers in position. This is held firm by a strong spring at the right end, and at the left end will be found a lever, whose lower left end rests on the upper end of the upright rod which springs from the side end of the pedal lever, while the upper end of it fits into a notch cut in the board. When the pedal is depressed, the rod is raised, and the board is pressed sideways. With the Celeste, this square lever is no longer required; it is unscrewed and removed.

For fitting with the Celeste pedal, 2 pedal levers are required, in order to support and work the 2 side rods that carry the lath to which the felt is attached. One pedal has to draw down both levers, so that the division between them must be shaped accordingly. The ends where friction occurs are covered with baize, and then rubbed with yellow soap. Generally the height of the side rods is determined by the height of the hammers. The damping felt is 1 in. wide at the treble end to $1\frac{1}{8}$ in. at the bass end, and $1\frac{1}{4}$ in. is glued on to the lath. The length of the felt is just a trifle over what is sufficient to cover the wires. The lath is $1\frac{1}{4}$ in. deep and $\frac{1}{4}$ in. thick, and fits into a slot at the upper end of each side rod, so that the top edge of the lath is level with the end of the rod. The side rods rest on the extreme ends of the pedal levers, to which they are attached by leather hinges; the mode of attachment will best be observed from the discarded side rod, which will be too short for use. These rods must run up quite close to the side walls of the piano, and their length will be such that the upper edge of the felt will rest ordinarily 1 in. below the line on which the hammers strike the strings. At about 6 in. down, a mortice is cut in each rod, and this works on a $1\frac{1}{2}$-in. screw, driven into the side wall. The length of the mortice is such, that when the pedal is down, and the rods are raised, the felt will cover the line on which the hammers strike the strings. A small circular felt washer lies between the rod and the wall, and another between the rod and the head of the screw. A strong band spring attached to the under side of the right lever, and acting on the floor of the piano, completes the mechanism. —(W. W. C.)

Harmoniums.—First purchase about 16 ft. of $\frac{3}{4}$-in. pine, about 1 ft. wide, and a plank of good sound beech, 3 ft. long, 7 in. wide, 2 in. thick at one end, and running off to $\frac{1}{2}$ in. thick at the other. Be particular as to the quality and soundness of the wood; it must be thoroughly well seasoned; and, in order to ensure its being thoroughly dry, kept in a warm room—but not too near a fire—for some weeks before being worked upon.

While the wood is drying, procure

your vibrators or reeds, from any harmonium-builder. Buy a good set of 54 notes, C C in the bass to F in the treble, being 4½ octaves. Prices of reeds run from 12*s.* 6*d.* to 25*s.* a set, according to quality; reeds can be purchased, together with leather for the bellows, and all other requisites, of Willis, 29 Minories. Also purchase the screws (about 15 dozen) for screwing the reeds to the sound-board. See that the reeds are well riveted, or they will soon get slack, and cause much trouble.

FIG. 192.

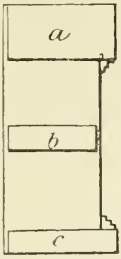


Fig. 192 is an elevation of the ends of the case: *a*, block or cheek; *b*, ledge; *c*, bottom block; *d*, groove for front panel. Fig. 193 shows under side of boards to carry feeders; Fig. 194, valve

FIG. 193.

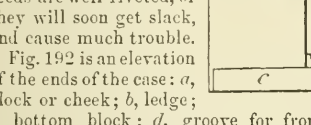


FIG. 194.

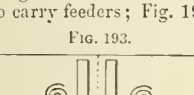


FIG. 195.

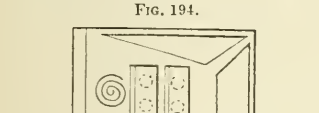


FIG. 196.

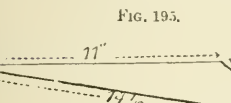
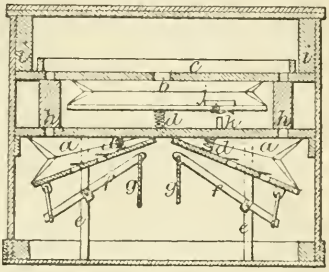


FIG. 197.

boards for feeders; Fig. 195, shape of pieces for sides of feeder; Fig. 196, shape of pieces for ends of feeder; Fig. 197, pair of ribs (black line at top shows where linen is glued on). Fig. 198 illustrates the arrangement of the interior:

FIG. 198.



a, feeders; *b*, reservoirs; *c*, wind-chest; *d*, spiral springs; *e*, supports for crank; *f*, cranks; *g*, cords for connecting ends of crank levers to foot-boards; *h*, wind-trunks; *i*, blocks or cheeks; *j*, safety valve; *k*, peg to open valve.

The Case.—The case must be got ready first, as the bellows and other parts are fitted to and supported by it. The wood may be pine, oak, mahogany, walnut, or rosewood. First make the ends, 2 ft. 7 in. high, about 12 in. wide in the narrowest part, and ½ in. thick. The top portion, to a depth of 7 in., projects about 2 in. at the front. This wider portion must be thickened by glueing and screwing a prepared block, 2 in. thick, on to the inside. The bottom part should also be blocked out to the same thickness, and 3 in. in depth. These blocks need not be solid, but may be made of ¾-in. stuff, and then veneered over where they will be in sight. An ornamental truss may be placed under the front of the top block, or cheek, or a turned pillar may run from the under side of the top block to the top of the bottom one, which will form a base for it. Now glue and screw a ledge of wood, ¾ in. wide and 3 in. deep, to each end, to support the bellows. These ledges, as also the cheeks, should not extend right across the end, but to within ½ in. of the back, so as to allow

the dust panel, or back, to be fitted in. A glance at Figs. 192 and 198 will explain these operations.

Prepare a panel of $\frac{5}{8}$-in. stuff for the front, 3 ft. 3 in. long, and 2 ft. high, with an opening cut in the bottom part, 1 ft. 8 in. long, and 8 in. high, to allow the feet to be placed on the foot-boards. This panel is let into the under side of the cheeks or blocks, about $\frac{1}{4}$ in.

Prepare a board 4 in. wide, 3 ft. 4 in. long, and 1 in. thick, and screw it at the bottom of the lower blocks, so that it may come right to the front, and lie flat on the floor. This is the foundation-board, on which the foot-boards for blowing will be hinged.

Take 2 boards, 3 ft. 3 in. long, and fix one to the top cheeks at the back, and one at the bottom.

Proceed to fit up the interior of the case. First prepare 2 boards, 3 ft. 2 in. long, 11 in. wide, and at least $\frac{3}{4}$ in. thick, to carry the feeders and reservoir. Plane them very true and smooth, then cut 2 holes in each, 6 in. long and 1 in. wide, at a distance of 3 in. from each end. Fig. 193 shows the under side of the board to carry the feeders, with 2 spiral springs fitted to it, and the holes cut in it for the wind-trunks. The springs are to cause the feeder to open when released from the pressure of the foot, and are termed "gape-springs." They may be made by cutting an ordinary spiral chair-spring in half, and placing each half in the position shown.

Feeders.—The feeders next claim attention. The under or valve boards are each 1 ft. 4 in. long, 10½ in. wide, and $\frac{3}{4}$ in thick. Bore 4 holes, 1½ in. diameter, through them, as shown in Fig. 191. These holes are to be covered by valves, which must be made as follows:—Glue 2 thicknesses of leather together (soft side outwards), leaving one 1 in. wider than the other; place them between 2 flat boards to dry, then cut them to size, and glue the single thickness down to the valve-board, thus forming a hinge to the valve. The valves may each be made to cover 2 holes, so that only 2 valves will be needed for each feeder. They should be $\frac{3}{4}$ in. larger all round than the holes which they cover.

Valve-boards.—The valve-boards are next hinged on to the feeder-board, and for this purpose a strip of $\frac{3}{8}$-in. wood, 1½ in. wide, is to be glued and screwed on to the under side of the feeder-board, and a similar strip on to the inside end of the valve-board. The valve-board may be hinged either with brass butt-hinges, or a strip of leather inside and out. Many prefer the latter mode, as there is no liability to squeak.

Feeder-folds.—The folds of the feeder may now be got out of $\frac{1}{4}$-in. board. You will require 8 pieces like Fig. 195 for the sides, and 4 pieces like Fig. 196 for the ends. The ends of each fold are cut to an angle of about 40°. Set these out very carefully, as it is important that they should be accurately made, or the feeders will be the source of constant annoyance and trouble. Procure some very soft, supple, white sheepskin, and cut it into strips (lengthways from the neck), about 1½ in. wide. Cut some strips of linen, about 1½ in. wide, across the stuff. Stand each pair of ribs side by side, with their short edges about $\frac{3}{16}$ in. apart, which you may secure by placing a strip of stout cardboard between them, and glue a strip of linen over the edges, as shown in Fig. 197. The linen will thus be on the inside when the folds are attached to the feeders. Let this dry, and then glue a strip of leather on the other side of the joint, grain side outwards. Then glue similar strips on the outside of the top and bottom edges, so that half the width of the leather overhangs all round. Fasten the spiral springs in their proper position on the valve-board, and then glue the overhanging leather of the folds on to the valve-board and feeder-board.

The inside must also have strips of linen on the joints, which you will be able to rub down with a strip of wood inserted through the corner holes where the gussets will be put on. When you have attached all the folds to the feeder and feeder-board, and well rubbed down all the leather, to make it adhere per-

fectly all over, let it dry thoroughly. Open the feeder to its full width, and cut a paper pattern of the gussets; cut them out in leather, and, after paring all the edges with a sharp knife, glue the gussets on, and rub them down well. A small triangular gusset-piece will be required for each corner where the valve-boards are hinged; and if brass hinges are used, a strip of leather must be glued all along the joint, to make it perfectly air-tight. When all this is done, clean off the leather with a sponge dipped in hot water; cover all the woodwork of the feeders with coloured or ornamental paper, and they will look very neat.

Wind-trunks.—Make the two wind-trunks of thin wood, $6\frac{1}{2}$ in. high, and slightly larger internally than the wind-holes.

Reservoir.—The reservoir is merely a rectangular bellows, with each fold $2\frac{1}{2}$ in. wide. Cut the ends of each fold to an angle of 40°, the same as the ends of the feeders. The bottom board of the bellows will be $\frac{5}{8}$ or $\frac{3}{4}$ in. thick, and a safety-valve must be made in it in the position shown in Fig. 198. This may be about $2\frac{1}{2}$ in. square, and covered by a valve of thin wood, lined with soft leather (soft side outwards), one end of which overhangs about 1 in., and is glued down to form a hinge. The valve is kept closed by a spring fastened through a little staple on the valve. A peg of wood, about $2\frac{1}{2}$ in. high, is fixed in the feeder-board immediately under the valve; so that as the bellows descends, the peg presses the valve open, and allows a little wind to escape, thus preventing undue pressure on the reservoir. A spiral spring is fixed to the centre of the under side of the reservoir, and to the top of the feeder-board. This spring exerts a constant pressure on the reservoir, and gives the force of wind necessary to cause the reeds to sound.

Foot-boards.—The foot-boards may be made of 1-in. deal, hinged on the under side of the front edge to the foundation-board already mentioned, and connected from the top by a cord to the lever arm, which is fixed into an axle working on centres in 2 uprights placed at the front and back of the inside of the case. Another arm extends from the other side of this axle immediately under the centre of the feeder, to which it is connected by a short lug. The general view will sufficiently explain this, the axle there being shown in section only. The foot-boards should have a ledge of $\frac{3}{4}$-in. stuff on the front edge, and they may be covered with a piece of carpet to make them look neat.

Wind-chest.—The reservoir having been completed, should now be fastened with glue to the reservoir-board, which has previously been referred to. This board lies on the top of the 2 wind-trunks, which should have a strip of leather run all round the top edges to make all air-tight.

The holes in the reservoir-board over the wind-trunks must be covered with leather valves to open upwards, made in a similar manner to those in the feeders. These valves are to prevent the return of the wind after it has been pumped into the wind-chest. A small hole, 4 in. long and 1 in. wide, is cut in the centre of the reservoir-board, to let the wind into the reservoir. If this is covered with a wooden valve lined with leather, so that it may be closed by pulling out a stop knob, you will have the stop termed "expression"; but if you do not wish for this stop—which is rather difficult to manage, and causes the breakage of many reeds by over-blowing—you will not require any valve over the hole, but may, if you like, make it rather smaller, and cut 2 more holes, 1 on each side of the central one, and about equidistant from that and the ends of the reservoir, as shown in Fig. 200.

To form the wind-chest, take some $\frac{1}{2}$-in. pine, $\frac{3}{4}$ in. wide, and glue it all round the top of the reservoir-board fair with edge of it at the sides, but 2 in. in from the ends, and plane it level all round, thus forming a shallow box $\frac{3}{4}$ in. deep. Now to see if your bellows answer, lay a strip of leather all round the edge of the wind-chest, screw a $\frac{1}{2}$-in. board tightly down on it, and glue some paper

all round the joints to prevent any escape of air; when dry, fit it into the case, placing a couple of long wedges under the cheeks to hold the reservoir-board firmly, and a screw or two through each end of the bellows board into the ledges. Press the foot-boards gently and fill the reservoir (do not overdo it), and then if your bellows is sound, and the valves act all right, the reservoir will take some minutes to empty itself. This board is only used to test the bellows, and does not form a part of the instrument. It is utterly impossible to make the bellows entirely without leakage.

Pan.—The pan or sound-board next claims attention. Take the beech plank before referred to, which is to be 2 ft. 7 in. long, 6 in. wide, 1½ in. thick at the bass end, and tapering off to ⅝ in. thick at the treble end. Plane this very truly on both sides, for it must not be touched with the plane after the subsequent operations. Take the width of the row of keys—which will be about 2 ft. 5¼ in. —and mark it on the sound-board, leaving 1 in. at the bass end and ¾ in. at the treble end; divide the 2 ft. 5¼ in. into 54 equal parts, and the lines thus made will be the centres of the mortices, which are set out as follows:—At a distance of 1½ in. from the back edge of the board, draw a straight line all along it; at the bass end, set off 1½ in. from that line on the first of the cross marks; at the treble end, set off ½ in. on the last cross mark, and join it by a sloping line to the bottom of the 1½ in. line, you will thus get the lengths of all the mortices. Then mark the widths of the mortices, which should be ¼ in. at the bass and diminishing to ⅛ in. at the treble. Cut the mortices right through the sound-board, and clear them out nice and smooth; those in the bass may be cut back on the under side, as shown by the dotted line in Fig. 199.

Cover the top of the board with a piece of stout veneer—sycamore being the best—which should be glued and clamped tightly down, and, when thoroughly dry, the pallet-holes may be cut through it, those at the bass end being 1 in. long and rather more than ⅛ in. wide, and gradually diminishing in size up to the treble. You can mark these out in the same way as the mortices. Having done this, take some ½-in. beech, or pine, 2 in. wide, and box round the edges of the sound-board fair on top side, the boxing projecting on the under side only. Now get out a bar of beech 1 in. square and 2 ft. 6 in. long, and glue it down on the top of the sound-board, so that the centre of it is 2¾ in. from the centre of the pallet-holes. Run a deep gauge mark all down the centre of the top of this bar to receive the centre wire on which the pallet levers work. Cut out 54 grooves in the bar in a line with the pallet-holes; this may be done by tying two small tenon saws together. Now make the pallets and levers, as in Fig. 199, the levers being made first and bored through the centre with a fine bradawl, or drill. The hole in the end to receive the long thin screw can be best made by screwing the lever lightly into a vice, and the screw can also then be inserted without danger of splitting the wood. The pallets themselves are made large enough to cover the holes well, and are tapered off at the top as shown. They are covered with soft leather on the under side, and whiting should be well rubbed into the leather with a little block of wood. In glueing the pallets on to the levers, some place a piece of stout soft leather between the lever and the pallet.

String the levers on to the centre wire, put them into the proper grooves, and press the centre wire down into the gauge mark; then glue a piece of wood ¼ in. thick on each end of the bar, with a hole in it level with the gauge mark to receive the ends of the centre wire, which may be drawn out from either end if required at any future time. Just at the back of the pallets, fasten a strip of wood exactly thick enough to be level with the tops of the levers; this is to fasten the pallet springs in. The springs are made of tolerably stout piano wire, bent into the form shown, the front end being turned up to run in a gauge mark on the top of the lever, the back end turned down and fixed into the

strip of wood above referred to; a small screw being inserted close behind it, so that the head holds the wire well down, or a small loop may be made in the end of the spring and the screw passed through that.

It may be of service to mention a plan for entirely dispensing with these steel springs. Bend some pieces of wire thus ⌐, and insert one between every pallet lever, just behind the centre bar. Then procure from a draper, 2½ yd. of covered elastic band that will stretch well, and, having made a loop at one end, slip it over the first wire crook, then over the first pallet lever, under the next crook, and over the next lever, and so on all through. This plan is simple and answers well; when the elastic does wear out, it can be renewed with very little trouble, and at a cost of only a few pence. The band should be ½ in. wide, and contain at least 6 strands of elastic.

The vibrators may now be screwed on to the under side of the sound-board in the position shown in Fig. 199, and the sound-board may then be considered complete. It should be hung by a peg through each end, which is made to project 3 in. for that purpose, the peg running into the cheek blocks, so that the sound-board may be turned down as on a hinge, and lie flat on the wind-chest. Make a little roll of cloth, cover it with soft leather, and fasten it all round the under side of the sound-board; then fix 2 iron hooks in the side, and 2 eyes in the wind-chest, so that when the sound-board is turned down on to the wind-chest, and the hooks are fastened into the eyes, there can be no escape of wind from the wind-chest, except through the vibrators and pallet-holes. The key-board will best be purchased, either new or second-hand. When it is placed in position, the screws in the ends of the levers should come under the proper keys, so that when the key is pressed down it opens the pallet belonging to that note.

A folding lid should be made to the case, and hinged at the back edge so that it may be turned right back if required to get at the interior of the instrument. Finish off the case in any style you may fancy, and your harmonium will be completed. If the case is made of mahogany, all that need be done is to French polish the exterior, but if it be made of pine, it should be stained and varnished, or ebonised.

FIG. 199.

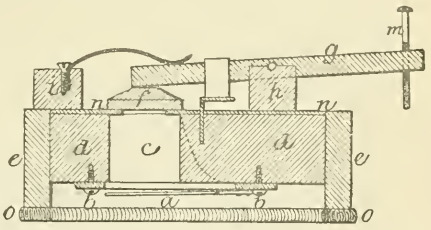


Fig. 199 is a sectional view of the bass end of the sound-board or pan: *a*, vibrator; *b*, screws by which vibrators are fixed; *c*, mortice; *d*, sound-board; *e*, beech boxing round sound-board; *f*, pallet; *g*, pallet lever; *h*, pallet lever-rail; *i*, spring rail; *j*, spring; *k*, wire crook; *l*, elastic band in lieu of steel spring; *m*, screw on which key rests; *n*, veneer; *o*, roll of cloth.

FIG. 200.

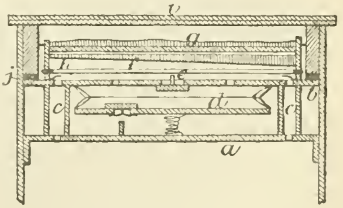


Fig. 200 illustrates a section of upper portion: *a*, bellows board; *b*, reservoir-board; *c*, wind-trunks, with valves at top; *d*, reservoir; *e*, expression valve; *f*, sound-board; *g*, pallet levers and rails; *h*, roll of cloth on edge of sound-

board; *i*, folding side to case; *j*, wedges to secure reservoir-board. (T. Main, in *Amateur Work*.)

Musical Boxes.—These delicate instruments are very liable to get out of repair, either by direct violence or by neglect, a small defect sufficing to render them temporarily useless. Whilst it would be futile for any one ignorant of their construction to attempt remedying accidental defects, a small knowledge of the first principles of their mechanism will enable any ordinarily handy workman to repair all but very serious injuries.

FIG. 201.

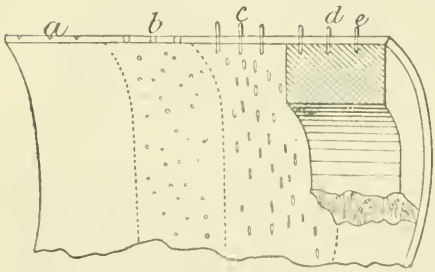


Fig. 201 illustrates part of a cylinder, broken, showing the progress of the 5 operations: *a*, pointing; *b*, boring; *c*, garnishing; *d*, gumming; *e*, turning.

The manufacture of a musical box may be divided into two very distinct parts. The first includes all that concerns the mechanical part of a box—that is, wheels, pinions, barrel, spring, fly-wheel, &c., or the "clockwork" of the box. The second concerns more particularly the musical part of the box, viz. putting the desired tunes on the cylinder, tuning the key-board, finishing these two parts and putting them in their proper places, so as to have a playing box. About the first part, it is necessary to say nothing, everything concerning it having a great resemblance to watches, and especially to clocks. Clocks and watches being universally found, and everywhere easily repaired, the case will be the same with the mechanism of a musical box. As to the second part. For finishing an ordinary musical box, the following processes are necessary:

First—The tunes are pointed on the cylinder. (Previous to this, of course, the choice of tunes is made, with the notes necessary for playing them.) This pointing is effected by an instrument in which the cylinder is placed on its 2 points. A needle on a dial serves to make the cylinder turn, in accordance with the measures of the music (tune), whilst the pointers glide from one end of the cylinder to the other, making small dots on the cylinder in accordance with the notes of the tune.

Second—At each one of these dots a hole must be bored, of the same size as the steel pegs. This is made by a very simple boring machine especially adapted for the purpose.

Third—In each of these holes a steel-tempered peg must be placed, and all forced into the same height above the cylinder. The pegs are long enough to have a part in the inside of the cylinder.

Fourth—The cylinder is partly filled with mastic gum, in order to fasten the steel pegs, and to give to the whole cylinder a certain consisteney.

Fifth—The cylinder is put on a lathe, and, with a file, is turned, so as to give to all the pegs a flat summit, and to make them all of a perfectly cylindrical surface.

Sixth—The key-board must be turned in accordance with the note put on the cylinder.

Seventh—This key-board must be attached by screws to the plate of the musical box.

Eighth—The ends of all the keys must be put in their right place, in respect to height (they must all be on a level), and with regard to the pegs of the cylinder.

Ninth—The key-board in place, each peg of the cylinder must be bent forward, so as to pass directly by the middle

of the point of the key corresponding, and more or less bent, so as to allow the key to produce its sound at the right instant; a special instrument with dial and hands is here again necessary.

Tenth—Steel spirals must be put at the end of each key, and bent in the right shape, so as to stop the vibration of the key each time a peg comes to lift it.

In the preceding description, several operations have been intentionally omitted which are of no great consequence for a general comprehension. Before giving further details, it will be necessary to make three preliminary remarks. The first is a precautionary suggestion, that great care should be taken never to take out any part of a box, except the key-board, without ascertaining whether the spring of the barrel is quite run down. It is easily understood that by lifting the keys of the key-board, if, for instance, the fly-wheel is removed, the spring being partly wound up, the cylinder, not being able to turn without the pegs attached to it, will revolve rapidly, and one of two things must happen, either the steel pegs of the cylinder will give way under the resistance of the key-board, and then break or be bent backwards, or, if the pegs be strong enough to resist, the key-board will be destroyed in pieces. Very often both cylinder and key-board may be broken in this way. Therefore, after having taken out the key-board, ascertain if the spring is at rest, and if not, let the box run down, and for more security, that no strain exists on the spring, lift the ratchet which hinders the spring from running backwards, and unwind it.

The second suggestion is: Before commencing to repair a box, observe at first if the pegs of the cylinder are all bent in the same direction, and if there be a few missing. If this be the case, there is all probability that the box need not be sent to the manufactory for repairs. But, if a certain number of pegs be wanting, or bent in all directions, especially backwards, no hope must be entertained of repairing the box, except at the manufactory itself, where all the particular tools are found necessary for making a musical box entire. In this way much expense may be avoided, and time and annoyance saved.

Thirdly, a very wrong impression is widely spread concerning the repairing of a musical box, which the writer will endeavour to correct. Very often a badly damaged key-board is alone sent to the manufacturer to be repaired or changed for a new one, or a new key-board is demanded to replace an old one, without sending back the whole box. In the actual state of manufacturing musical boxes, it is impossible to make a new key-board for a given cylinder, or the reverse—a new cylinder for a certain key-board—without having in hand the entire musical box. These two parts, which are the two most important of a box, are too closely connected to permit the mending of one without the other, or without the plate which carries them both. It is only when one or two keys are broken that it is possible to replace them without the entire box.

We have now given, in a brief way, an idea of the manner in which a musical box is made, and the indications when a box should be repaired at the manufacturer's, or elsewhere. We will now admit that the cylinder is in sufficiently good condition, and will mention, one after another, the accidents which may be easily repaired by any skilled workman, possessing ordinary tools.

Next to the cylinder, one of the most important parts of the musical box is the key-board. We will first see how all accidents happening to a key-board can be remedied.

It is well known that the number of vibrations of a pendulum in a given time, is regulated by the weight of the pendulum-ball. The heavier it is, the more slowly will it vibrate, and the lighter it is, the more quickly it will go. The same is to be found with the key of a key-board, which is nothing but the half of a tuning-fork.

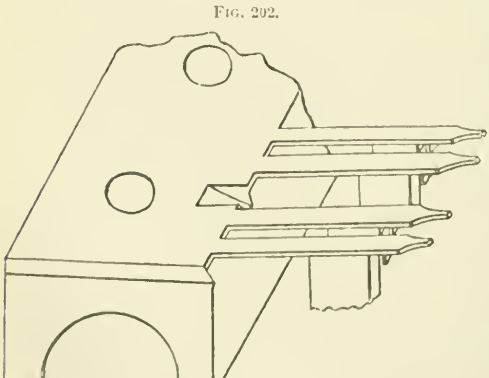
The lower tones giving a less number of vibrations in a second than the higher ones, it will suffice to load the end of

the key to lower the tone, and to lighten it to have a higher tone. It will also be easily understood that a thick key or a short one will vibrate more quickly than a thin or long one. After these suggestions, it will be very easy for any one to put any number of keys to the right tone.

Any person having had a key-board in hand, will have noticed that there are two kinds of keys; some having lead at the end, and others that have none. For those having lead, it will be sufficient to cut some of it to elevate the tone, and to file the key between the lead and the brass plot, to lower it. For those without lead, the same must be done to lower the tone, but having no lead, must be filed near the end underneath, to elevate it. As you must avoid having any thin keys (these not possessing good sound). instead of filing a key to lower it, it will be often preferable to change the lead for a heavier one, or supply the deficiency by solder.

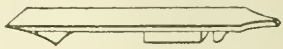
We have now to see in what manner a missing tooth may be replaced. Take a piece of steel and make a key of the

FIG. 202.



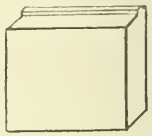
same shape as the missing one, or the adjacent ones, but on the under part a heel must be devised, as indicated in Fig. 203. In the steel block of the key-board, with a file of the width of the key, make a notch as indicated by Fig. 202. Hammer the new key in its place, so that the heel will exactly fill the hollow space, and so that the key will be placed as much as possible in

FIG. 203.



the right direction and right level. In making the new key, the point must be made a little longer and a little wider than the adjacent ones. Then temper

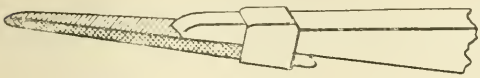
FIG 204.



the new key, draw it to a dark blue, so that it will vibrate like a good spring, and at the same time so that it can be filed. Whiten the heel of the key, put it in place, and solder it. This must be done with a soldering bit, which weighs at least 6–8 lb., so as to retain sufficient heat. Lay the copper pretty hot on the key when in its place, and after a few moments' delay the solder will run. The solder and acid are the same as used by tinmen. The key, well fixed, must then be finished, filed on the top to a level with the other keys, and tuned by filing it underneath. It is necessary here to say in what way the under part of a key can be easily filed. Put in the vice a small block of steel or brass, a little thicker than the key is wide, about $\frac{3}{4}$ in. long, with a small elevation, lengthwise. Place the key to be filed on this block, the whole comb being held in the hand under side up, and with a certain

pressure the key will rise above the others, and will be easily filed with a square file $\frac{3}{16}$ in. wide, and 6 in. long. When the key to be filed is in the middle

FIG. 205.



of a long key-board, it will be advantageous to make an appropriate handle to the file, as indicated in Fig. 205.

The point of the key must then be finished, that is, filed to its proper width (to correspond to the other points), and, at the same time, brought as nearly as possible to the same distance from the two adjacent points. For putting the point to its exact length, it would be well to hold the key-board with the keys perpendicularly on a piece of flat window-glass, and by reflection it will be easily seen when it is brought to the same length as the others.

Place the point of the key, when it is filed to the right width, as nearly as possible to its level, and proper distance from the adjacent ones. Sometimes it may be found necessary, however, to change the place of the point of a key; to lower it so as to put it on a level with the other ones, or to shift it to the right or left. In this case, a small anvil must be made, well tempered, of about the same shape as the one used for filing the keys, but quite flat on top, with no elevation. The hammer used must have one end tempered, with the end a little rounded and not too sharp. If a key is forged on the left angle, it will move to the right, and *vice versâ*. The key must be forged on the under side. Here a certain practice is quite necessary; the key must be well placed on the anvil, the spot to be reforged resting well on it, and 2 or 3 strokes of the hammer will make the key move a little.

To lower or elevate a key, another anvil of the same size as the preceding one is necessary, tempered, but notched on the top (Fig. 206). The key is laid lengthwise and quite flat on this anvil, and by striking the key with the other end of the hammer (Fig. 207), which is flat and not tempered, the key will bend upwards. In both these cases much care must be taken, as it is very easy to break a key in using this hammer.

In case only a point of a key is broken, it is not necessary to replace the whole key. With the blowpipe, the end of the key must be untempered, but care must be taken that the flexible part of the key be not beaten and untempered (the sound would be lost); a small notch is made with a narrow file, and a small piece of spring is filed and pressed in. It will be easily soldered with a small soldering bit. Then the point must be finished as already indicated.

FIG. 206.

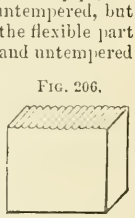
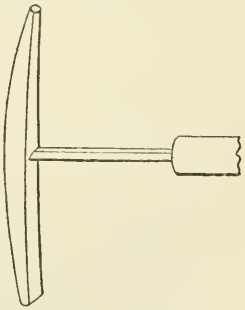


FIG. 207.

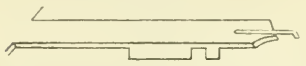


It may be well to remark here, that when a key is untempered and has no sound, it will sometimes regain sound by drawing it to a blue with the blowpipe, without previously tempering it.

Now the whole key-board being complete, no keys or points missing, it must be put on the musical box-plate, and the line of small dots, which every cylinder carries, will serve to indicate if all the points of the key-board occupy their

right places. This can also be seen by the pegs; when the cylinder turns, the pegs must all come exactly under the middle of each point of the key-board.

FIG. 208.



When it is ascertained that all the points are in their places, the key-board must be finished completely,—that is, all missing spirals replaced, and the key-board then definitely tuned.

The tuning must always be done twice, because all operations upon a key change its tone a little, even when a spiral is changed; and before hammering a key, it must be brought to the proper thickness and about to its right tone. It may be advisable here to remark that in the first tuning it is well to leave the key half a tone too high, because putting a spiral at its end lowers the tone, and in general it is easier to lower the tone than to elevate it.

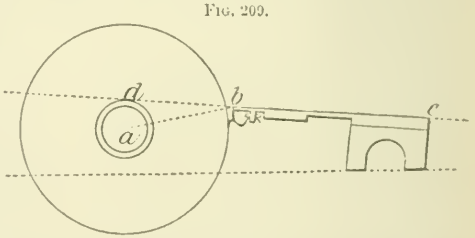
There remains now only to be seen what form must be given to the spirals, how to put the key-board in its right place, and, in general, how to have a good playing musical box.

The manner of repairing all defects in a musical box has now been indicated. The mechanical part now runs well, the key-board is repaired, tuned, and in good condition. Before indicating the form which must be given to the spirals of the key-board, and how to place the key-board itself in its right position, we offer the following suggestions.

The cylinder must be free to move easily up the 6, 8, or 10 tunes, as the case may be, and fall back readily to the first tune, being regulated by the spring at the left end of the cylinder. But care must principally be taken that the axis of the cylinder turns freely; on the other hand, it must have no play whatever to move lengthwise between the two bridges. If the least play exists, it will be utterly impossible to finish the box properly. The pegs of the cylinder must necessarily follow exactly under the points of the keys; if not, the box will never play well. If any play be found, it will easily be removed by bending the legs of one of the bridges of the axis.

This done, the spirals of the key-board must be bent their right shape, and the key-board put in its proper place. It will be well in a few words to describe the theory of the spiral, this being a very important part of the musical box. The manner in which these small steel stiffers are bent contributes very much toward making an excellent box. The upper side of the key-board must always make the same angle of the radius of the cylinder, passing through the point of the keys. This angle *a*, *b*, *c*, Fig. 209, must be 165°, or, which is the same

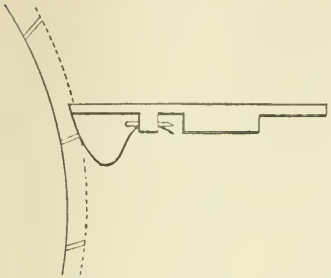
FIG. 209.



thing, angle *a b d* equal to 15°. It is not very easy to measure this angle, but in practice the following will amount to about the same results. Supposing the diameter of the cylinder to be $2\frac{1}{8}$ in., *a d* must be $\frac{1}{4}$ in. It will be observed that the upper level of the key-board, *b c*, prolonged, will attain pretty exactly the summing of the spring at the end of the cylinder. Supposing this to be the case, the spiral must have the shape indicated in Fig. 210 magnified. The end of the spiral must be as near the point of the key as possible without touching it. It must be observed that the heavier a key is (or the lower the tone) the thicker must be the spiral, as it is more difficult to stop the vibrations

of the key. As the cylinder turns, the peg will first touch the spiral at about the last third part (in Fig. 210 the peg

Fig. 210.



is at the place where it should commence to touch the spiral), the spiral will fall back, and when the peg has reached the end of the key, the vibration of the key will have stopped. If the spiral is too thin, the peg will readily pinch it (it must then be changed), and will not sufficiently stop the vibrations; or if too thick, the spiral itself will produce a buzzing noise in stopping the vibrations of the key. To see if the spiral has a good shape and works properly, it will be best to let the box play slowly, the key-board in its place, and examine how the pegs act on the spirals, and see that they do not get out of place. Some practice will be necessary here to find out if the spirals must be bent forward (when they do not sufficiently stop the vibrations), or backward (when they make too much noise, or are pinched). For bending these spirals a pair of pliers (Fig. 211) with a hook at each end will be necessary. It must not be forgotten that the shape and strength of the spiral, its distance from the end of the key, its place backward or forward, all have an importance which must not be overlooked.

Fig. 211.

The only thing remaining now is to put the key-board in its proper place. 1st. As to height. The dotted line which is found on each cylinder will here serve as a guide; but it must be observed that, supposing the shortest key to be on a level with the dots, the longest ones must be a little below, about the distance of half a dot. This difference in level gives the difference in "rise" of the keys, the longer ones necessitating more rise than the shorter ones. If this level should not be right, the key-board must be left as it is, and one of the bridges must be raised or lowered accordingly.

2nd. The key-board must occupy the right place, as to left and right. That is, all the pegs must pass directly in the centre of the points of the keys. It will facilitate matters to observe if the points of the keys pass at the same distance between the pegs of the two adjacent tunes. Should they not, the cylinder or the key-board must be shifted right or left; the key-board by bending the feet in the opposite direction, the barrel by filing or elevating the metal piece which rests on the tune counter placed on the inside of the toothed wheel of the cylinder.

3rd. A good rise must be given to the keys of the key-board. If they rise too little, they will have but little sound; if too much, they will have a disagreeable sound, and, moreover, it will be difficult for the spirals to stop the vibrations, or they will make a noise and get pinched. At the same time it must be carefully examined if the different keys produce their sound at the same moment; that is, in those parts of the tune when it is easy to observe that they should. This will be readily seen by letting the box play slowly. When the sounds are produced too late, the part of the key-board where this occurs must be put a little backwards, and if too soon it must be put a little forwards. This is obtained by bending the feet of the key-board in the opposite direction.

When the key-board is mended and tuned, it would be well to suggest that the spirals be bent only approximately, until after these last operations are

completed, when the last touch must be given to the spirals, in order to obtain a musical box playing smoothly and agreeably.

After all this is done, it would be well to let the box play through all the tunes, and correct all the pegs that may have lost their right position, either right or left, by producing a disagreeable noise, by touching the ends of the keys when they should not, or by playing too soon or too late. When they play too soon the pegs must be bent backwards; when too late, forwards.

The case may happen that 3 or 4 tunes play quite well, and at the fifth one, for instance, all the pegs pass over the side of the ends of the keys. This will be corrected by touching that part of the counting wheel which gives the said tune.

Let us now resume, in a few words, the order in which all these different repairs are to be effected.

First, repair all concerning the mechanical part of the box, until, without the key-board, every wheel runs well. See that the axis of the cylinder has no play lengthwise, then that the cylinder moves freely on its axis. Repair all missing keys and points of the key-board, file the new keys half a tone too high, put all the points on a level and at the right distance from each other, place all the spirals, bend them appropriately, tune the keys definitely, put the key-board in its right place, finish the bending of the spirals to their proper shape, and then correct all pegs on the cylinder.

It often occurs when a musical box plays that the pleasure is destroyed by a continual buzzing noise, produced always by a piece of metal or wood not properly fastened. The best way to find out what part of the musical box produces this disturbing noise is to let the box stop, and make the keys resound from one end of the key-board to the other with a rounded point; the notes which cause this noise will soon be discovered, then continue with one hand to produce this sound, and at the same time with the other hand touch all possible parts of the box which seem to produce the noise, and as soon as, by touching, the noise ceases, the object has been discovered. Tightening the screw, or a drop of oil, will very often do away with the noise.

CLOCK AND WATCH MENDING. — In executing ordinary repairs to clocks and watches, there is nothing of such an intricate or difficult character that it cannot be undertaken by any one possessing some skill and dexterity in handling delicate tools. On the other hand, it would be folly for the same person to attempt to make a clock or watch without having studied the art as a trade, and being provided with all the necessary and expensive outfit.

Clocks.—It will be best to begin with clocks, as their works are on a larger scale and more easily understood.

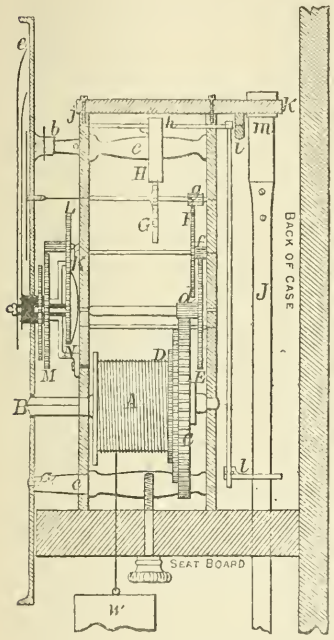
8-day Clock.—As far as the "going" part of clocks is concerned—and that is the part liable to injury and wear—the ordinary 8-day English house-clock may be taken as the type.

The interior of such a clock is shown in side section in Fig. 212: a rope is coiled round the barrel A, 16 times for the 8 days, and the barrel is fixed to its arbor B, a prolongation of which is the square winding pin that comes out on the face of the clock. The dial plate or face is fixed by small screws *a* or by sockets and pins *b*, to some 4 or 5 legs *c* which join the front and back plates of the clock frame; frequently the dial is provided with a special set of legs of its own. On the arbor B also rides the great wheel C, which is connected with the barrel by the ratchet D. The great wheel drives the centre pinion *d* on the arbor of the centre wheel E, which is prolonged outside the dial plate and carries the "minute" or long hand *e*.

The centre wheel makes 1 revolution in an hour, and the great wheel 1 in 12 hours, by being provided with 12 times as many teeth as the centre pinion. The centre wheel drives the second wheel F by its pinion *f*, and that again drives the escape wheel G by its pinion *g*. If the pinions *f g* have each 8 "leaves"

(the teeth of pinions are so called), E will have 64 teeth and F 60, in a clock whose escape wheel revolves once in a minute, so that the seconds hand may

FIG. 212.



be set on its arbor prolonged to the face of the clock. The arbor *h* of the pallets of the escapement H goes through a large hole in the back plate near *i*, and its back pivot turns in a cock *j i k* screwed on to the back plate.

From the pallet arbor at *i* descends the crutch *i l*, ending in the fork *l*, which embraces the pendulum J, so that, as the pendulum vibrates, the crutch and pallets necessarily vibrate with it. The pendulum is hung by a thin spring *m* from the cock *k* so that the bending point of the spring shall be *just opposite* the end of the pallet arbor, and the edge of the spring *as close as possible to the end of that arbor*.

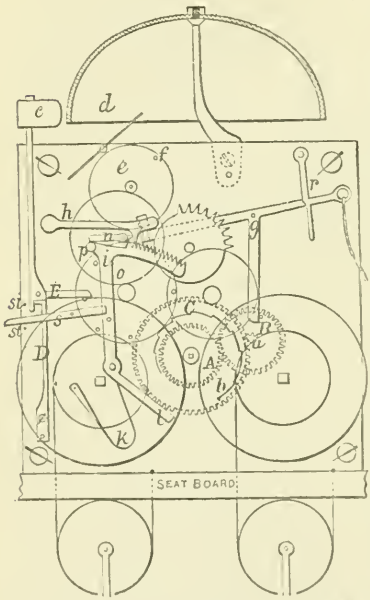
Of the "motion work" of the clock, the first thing to notice is the minute hand, which fits on the square end of a brass socket fixed to the wheel K, and sits closely but not tightly on the projecting arbor of the centre wheel. Behind this wheel comes a bent spring, which should be set on the same arbor with a square hole in the middle, so that it turns with the arbor. The wheel is pressed against this spring, and is kept there by a cap and a small pin through the end of the arbor: consequently there is sufficient friction between the spring and the wheel to carry the hand round, but not enough to resist a moderate push with the finger for the purpose of altering the time indicated. This wheel K, usually called the minute wheel but is really an hour wheel, drives another L having the same number of teeth, and a pinion attached to it; this pinion drives the 12-hour wheel M, also attached to a large socket or pipe carrying the hour hand, riding (to relieve the centre arbor of extra weight) on an intermediate socket fixed to the bridge N, which is screwed to the front plate over the minute wheel K.

A heavy weight *w*, which drives the train, and gives the impulse to the pendulum through the escapement, is generally hung by a catgut line passing through a pulley attached to the weight, the other end of the cord being tied to some convenient projection in the clock frame or seat-board, to which it is fixed by screws through the lower legs.

It is a common practice to make the cases of house clocks 6 ft. high; this is a great waste of space and materials. The case need only be long enough to give the pendulum full play, if the size of the barrel is diminished, or the great wheel is increased in diameter, or the weights are hung on a treble instead of a double line, at the same time increasing the weights in a progressive ratio to overcome the additional friction.

Fig. 213 represents a front view of the clock minus its face, thus exposing the repeating or rack striking movement. On the pipe of the hour wheel A the

FIG. 213.



minute hand is set. B is the reversed hour wheel with its pinion *a*, driving the 12-hour wheel C, on whose socket is fastened the snail *b*, belonging to the striking work exclusively. The hammer *c* is raised by the 8 pins in the rim of the second wheel in the striking train; it does not quite touch the bell *d*, or it would cause a jar in striking. The spring D is arranged both to drive the hammer against the bell when the tail k is raised, and to check the hammer just before reaching the bell, so that the blow on the bell is due to the hammer having acquired sufficient momentum to carry it a little beyond its place of rest. Occasionally one spring is used to impel the hammer and another to check it; the latter may be replaced by a piece of vulcanised rubber tied round the leg where the hammer shank approaches it. To reduce the chattering of a heavy hammer, make it lean forward so as to act partially by its weight.

As a rule, the pinion of the striking wheel has 8 leaves; and as a clock strikes 78 times in 12 hours, the great wheel will revolve in that period if it has 78 teeth instead of 96, which the great wheel of the going part has for a centre pinion of 8. The striking wheel drives the wheel above it once round for each blow, and that wheel drives a fourth *e*, on which is a single pin *f*, 6, or any integral number of turns for 1 turn of its own; that again drives a fan fly to moderate the velocity of the train.

The reversed hour wheel B is so adjusted that, within a few minutes of the hour, the pin in it raises the lifting-piece *q* so far that the latter disengages the click *h* out of the teeth of the rack *i*, which, helped by a spring *k* near the bottom, immediately falls back as far as it is permitted by its tail *l* coming into contact with the snail *b*. It is so arranged that the number of teeth which pass the click is proportionate to the depth of the snail; and as there is one stop in the snail for each hour, and it goes round with the hour hand, the rack always drops just as many teeth as the number of the hour to be struck. This drop makes the noise known as "giving warning." The clock is not ready to strike till the lifting-piece has fallen again: for as soon as the rack was let off, the tail of the gathering pallet *n*, on the prolonged arbor of the third wheel *o*, was enabled to pass the pin *p* of the rack on which it was pressing before, and the striking train began to move; but before the fourth wheel *e* had made half a revolution, its pin *f* was caught by the end of the lifting-piece, which is bent back and goes through a hole in the plate, and when raised stands in the way of the pin *f*, so that the train cannot go on

till the lifting-piece drops, which it does exactly at the hour, by the pin on the wheel *e* slipping past it.

The train is then free. The striking wheel begins to lift the hammer, and the gathering pallet catches up the rack, a tooth for each blow, till it has returned to the place at which the pallet is stopped by the pin *p* coming under it. The lifting-piece is prolonged to E, where a string is hung to it; this is the proper place for such a string when it is wanted for the purpose of learning the hour in the dark. It is generally put on the click *h*; but in this case, if held too long the clock will strike too many, and if the string accidentally sticks in the case, the clock will go on striking till it is run down. The click *r* only exists in clocks which strike the quarters. The lever *s* controls the striking: if pushed up to *s i*, the other end will meet a pin in the rack and prevent the striking.

Repairing. — Having described and illustrated the mechanism of the 8-day clock, it will be an easy matter to give directions for effecting simple repairs.

After taken the movement from its case, removing the hands, dial, minute cock, and bridge, try the escapement with some power on, and note any faults there. Next remove the cock and pallets—putting a peg between the escape-wheel arms to prevent it from running down — and carefully let down the spring. Here sometimes you will meet with a difficulty; if the spring has been set up too far, and the clock is fully wound up, it may not be possible to move the barrel arbor sufficiently to get the click out of the ratchet. In many old clocks there will be found a contrivance to meet this difficulty. It is simply a hole drilled at the bottom of, and between the great wheel teeth directly over the tail of the click; so that you can put a key on the fusee square and the point of a fine joint pusher through the hole, release the click, and allow the fusee to turn gently back until it is down. This is a great convenience sometimes. Having let down the spring, try all pivots for wide holes, and if it is a striking clock, do the same with the striking train, paying particular attention to the pallet-pinion front pivot to see if it is worn, and the rack depth made unsafe thereby—also seeing that none of the rack teeth are bent or broken. Having noted the faults, if any, take the clock to pieces, and look over all the pivots, and note those that require repolishing. Finally, take out the barrel cover, and see to the condition of the springs—if exhausted or soft.

In most cases, some repairs will be required to the pallets, as these nearly always show signs of wear first; if they are not much cut, the marks can be polished out without much trouble—and for this purpose you will find that a small disc of corundum about 3 in. in diameter, mounted truly on an arbor, and run at a high speed in the lathe, will be of great assistance; finishing off with the iron or steel polisher and sharp red stuff. If you have to close the pallets to make the escape correct, see that the pallet arms are not left hard, or you may break them.

After making any alteration in the pallets, you will generally find it necessary to correct the depth; should it only require a slight alteration, probably it will be sufficient to knock out the steady-pins in the cock, and screw it on so that it can be shifted by the fingers until you have got the depth correct, then screw it tight and broach out the steady-pin holes, and fit new pins. Sometimes one meets with a pallet arbor that has been bent to correct the depth. This is a practice that cannot be too strongly condemned, as it throws an unequal pressure on the pivots, and causes them to cut rapidly. If much alteration in the depth is required, it may be necessary to put in a new back pallet hole; this can be made from a piece of hollow stopping broached out and turned true on an arbor, and to a length equal to the thickness of the plate. It is not safe to rely on the truth of this stopping, unless it is turned on an arbor first. The hole in the plate is now drawn in the direction

required with the round file, and opened with a broach from the inside until the stopping enters about half way. Of course, in finishing broaching the hole, you will roughen the extremities to form rivets. Drive the stopping in, and rivet it with a round-faced punch from the outside, reverse it, rest the stopping on the punch, and rivet the inside with the pane of the hammer; remove any excess of brass with the file, chamfer out the oil sink, and stone off any file marks; finally opening the hole for the pivot to the proper size. If you have a depth tool that will take in the escape wheel and pallets, it will be quicker to put them in the tool, fill up both holes with solid stoppings, and replant them; but few workmen have a large depth tool.

Very frequently you meet with a scape pinion that has become so badly cut or worn as to be useless, and you cannot always purchase a new one of the right size; in this case, it will be necessary to make it from the wire, which you can always obtain of every size at the tool shops. In sectoring the pinion wire to the wheel, bear in mind that it will become slightly smaller in filing up. Considerable practice is required to make good-shaped pinions quickly and well. A piece of pinion wire of a slightly greater diameter than the pinion is to be when finished, is cut about $\frac{1}{8}$ in. longer than required, and the position of the leaves or head is marked with 2 notches with a file. The leaved portion of the wire that is not required, is now carefully filed down on a filing block, taking care not to remove any of the arbor in so doing; a centre is then filed at each end true with the arbor, and these centres are turned true through a hole in a runner or centre in the throw. If this has been carefully done, the pinion will be nearly true; it is now set quite true, and the arbor and faces of the pinion are turned square and smooth. The pinion is now filed out true, using a hollow-edged bottoming file for the spaces, and a pinion-rounding file for the sides of the leaves. In using the bottoming file, the pinion is rested in a gallows tool described, and held in the fingers for the leaves, when finishing, to keep them flat.

The file marks are now taken out with fine emery and oil; the polishers used for this purpose are pieces of wainscot oak, about $\frac{1}{4}$ in. thick, 5 in. broad, and 6 in. long, used endway of the grain. One end is planed to a V shape to go between the leaves, and the other is cut into grooves by rubbing it on the sharp edges of the pinion itself, which speedily cuts it into grooves to fit. The pinion is rested while polishing in a groove cut in a block of soft deal, which allows it to give to the hand, and keeps it flat. When the file marks are all out, the pinion is ready for hardening. Twist a piece of stout binding wire round it, and cover it with soap; heat it carefully in a clear fire, and quench it in a pail of water that has been stirred into a whirlpool by an assistant, taking care to dip it vertically. Having dried it, it is covered with tallow and held over a clear fire until the tallow catches fire; it is allowed to burn for a moment, and then blown out and permitted to cool. The leaves are now polished out with crocus and oil in the same way that they previously were with emery.

Now, if the pinion is put in the centres and tried, it will probably be found to have warped a little in hardening. This is corrected in the following manner: The rounding side of the arbor is laid on a soft iron stake, and the hollow side is stretched by a series of light blows with the pane of the hammer, given at regular intervals along the curve. Having got the leaves to run quite true by this means, turn both arbors true, and polish them with the double sticks—these are simply 2 pieces of thin boxwood, about $\frac{3}{8}$ in. wide and 3 in. long, fastened together at one extremity and open at the other; between these the arbor is pinched with oil and fine emery, and they are traversed from end to end, to take out the graver marks. The brass for the collet, to which the wheel is riveted, is now drilled, broached, and turned roughly

to shape on an arbor. The position on the pinion arbor is marked with a fine nick, and the collet is soldered on with soft solder and a spirit lamp, taking care not to draw the temper of the arbor when doing so. Wash it out in soda and water, and polish the arbors with crocus, turn the collet true, and fit the wheel on. If the pinion face is to be polished, it is now done, the facing tool being a piece of iron about $\frac{1}{16}$ in. thick, with a slit in it to fit over the arbor with slight freedom, and using oil-stone dust first, and then sharp red stuff.

Generally, cut pinions are used for the centres, and in this case the body of the arbor is sufficiently large to allow the front pivot to be made from the solid arbor; but in some movements, particularly those used for spring dials, the centre pinions are made from pinion wire in the manner just described; but for the front pivot a hollow tube of hardened and tempered steel is soldered on to the arbor. This piece should always project sufficiently far through the pivot hole to allow it to be squared to receive the friction spring which carries the motion work. In cases where this pivot is much cut, it is best to remove this piece and substitute a new one, and as these pinions are very long and flexible, some difficulty will be experienced in turning this pivot unless some form of backstay is used to support the arbor, and prevent it springing from the graver.

In common clocks, where both third and escape pinions are worn by the wheel teeth, if the pivots are still in good condition, and the expense of new pinions is objected to, very good results can be obtained by the following alteration. The third pinion leaves must be turned back from the outer end rather more than the thickness of the centre wheel, the pivot shoulder also turned back the same distance, the pivot remade, burnished, and shortened. Then the pivot hole in the front plate is carefully opened with a broach to about twice its original size, and a stopping with a good large shoulder is turned true on an arbor and riveted into the plate. The thickness of the shoulder of this stopping will depend on the amount that you have shortened the arbor, and must be such as just to give correct end-shake to the pinion. By shifting the third wheel and its pinion thus, a fresh portion of both the third and escape pinions is brought into action, and as good results will be obtained as by putting 2 new pinions, with a very small expenditure of time and trouble.

One often finds in old clocks that the escape wheel is so much out of truth that anything like close scaping is out of the question, as so much drop has to be given to enable some teeth to escape, that nearly all the power is lost; in such a case a new wheel is a necessity, and if you want to get a good hard wheel you must make the blank yourself. Take a piece of hard sheet brass, about twice as thick as the wheel is to be when finished, and cut from it a square sufficiently large for your wheel; then with a hammer with a slightly rounded face, reduce it to nearly the thickness you require. In hammering, go regularly over the surface, so that no 2 consecutive blows fall on the same spot; and when one side is done, turn it over, and treat the other in the same way. File one side flat, find the centre, and drill a hole nearly as large as required for the collet; cement it with shellac to a flat-faced chuck in the lathe, and centre it true by the centre hole. Mark with the graver the size of the wheel, and with a narrow cutter remove the corners; face the blank with the graver, and turn it to size, leaving it slightly larger than the old wheel; knock it off the chuck and reverse it, bringing the turned face next the chuck, turn that face flat and to thickness, and it is ready for cutting. After it is cut, remove any burrs with a fine file, and mark a circle to show the thickness of the rim, and on that circle divide it into the number of arms it is to have; mark also a smaller circle slightly larger than the collet on which it is to be riveted, draw lines through the divisions in the outer circle and the centre of wheel to mark the centre of the arms. Drill a hole be-

tween each 2 arms to enable you to enter the file, which to begin with should be a coarse round one, then follow with the crossing file, holding the wheel between a piece of thick card in the vice; finish by draw-filing the arms and crosses with a very smooth file, followed by a half-round scraper used as when draw-filing. This leaves the surface smooth and ready for the burnisher, of which tool two different shapes will be required, one oval, and the other half-round. These tools, when in use, require to be repeatedly cleaned on a piece of leather, and passed over the palm of the hand, to prevent tearing up the surface of the metal. The wheel teeth are now polished out with a short-haired brush and fine crocus and oil; then take out the file marks from both sides of the wheel with water-of-Ayr stone and oil, and it is ready for riveting on.

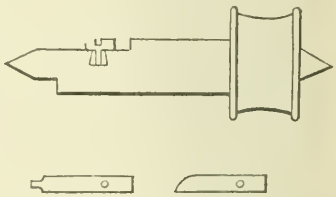
The riveting stake for clockwork is exactly like the ordinary pinion riveting stake used by watchmakers, only it is in 2 pieces dividing down the centre of the holes; if it were in one piece, the pinion head would prevent it passing through a hole of the proper size to fit the collet; it has 2 steady pins to ensure its coming together properly. Take a slight chamfer out of the front of the wheel hole, and roughen the surface of it with a graver, turn the collet down to fit in tightly, and rivet it on with a half-round punch, taking care to strike light blows and keep the wheel turning while riveting. It is then ready for stoning off and polishing with a flat wood polisher and fine crocus and oil. In crossing out a small delicate wheel, it is a good plan to fasten it with shellac to a flat plate of brass, having a hole in it rather larger than the inside of the rim of the wheel. In this way all danger of bending a tooth of the wheel accidentally is avoided, and the crossing can be finished without removing it from the plate.

A few hints on cutting escape wheels may be useful to those who possess a wheel-cutting engine.

The form of cutter used for brass wheels is what is commonly known as a fly, or single-tooth cutter, driven at a very high velocity. If the cutter is of proper form and well polished, and the blank to be cut is firmly supported, the teeth cut will have a perfectly smooth polished surface, requiring no further finishing.

There are several forms of spindle in use to carry single-tooth cutters. The one shown in Fig. 214 is very convenient, and easy to make. A plain steel arbor $2\frac{1}{4}$ in. long and $\frac{5}{10}$ in. diameter is centred, and turned down at the left end for a short distance, to receive the brass pulley by means of which the spindle is driven; the other extremity of the arbor is also turned down for a length of $\frac{3}{8}$ in., to about $\frac{1}{4}$ in. diameter. A flat is filed on one side of the arbor for nearly half its length, until it is level with the reduced extremity of the arbor. A taper dovetail groove is then filed at right angles to the axis of the arbor and down to its centre to receive the cutter (this groove should taper so that the cutter enters tail first), and at the centre a hole is drilled, tapped, and a screw fitted as shown to secure the cutter in position. The extremities of the arbor are now hardened and let down to a full straw colour, the pulley is driven on and turned true, and both centres are finished to fit the centre screws accurately.

FIG. 214.



The cutters are made from square steel, carefully filed to fit the groove in the cutter spindle, and when properly fitted, knocked gently in with a light hammer; a hole is drilled to correspond with the screw hole in the spindle. The cutter is now filed out to the shape

required, using the old wheel as a gauge; for a small engine, the cutter should not project more than $\frac{5}{16}$ in. beyond the arbor. The angle at which the cutter is sharpened must be but little less than 90° (if made more acute, the cutter will chatter and not cut a smooth surface); of course, in filing, the angle will be made less than this, but in the final smoothing and polishing it must be increased to this. After it is filed to shape, it is knocked out of the spindle, covered with soap, and hardened—the face rubbed bright and tempered to a straw colour—the shank being let down still softer to prevent its breaking. The flat side and face of the cutter are smoothed with oilstone dust, and polished with either diamantine or red stuff on a bell-metal polisher, and the curved edge is done in the ordinary lever-end tool. Every portion of the cutting edge must be perfectly smooth and polished, or it will not produce a smooth surface on the wheel; when in use, if at any time the cutter is found to have a film of brass forming on the edge, it should be re-sharpened and polished at once. With a cutter of this description working on brass it will be found difficult to drive it too fast.

In adjusting the cutter in the engine, in order that the angle of the wheel teeth may be kept the same as in the original wheel, the old wheel is placed in position in the engine, and centred by the pump centre, then the cutter spindle is adjusted by its screws until the cutter passes freely between 2 teeth, when the set-screws are tightened. It will be found best, if accurate work is desired, to remove the greater part of the material at one cut, and then to finish with a very slight cut at last. The cutter must not be forced, but passed through at one uniform speed, rather too slow than fast, and kept liberally supplied with oil while cutting. If a cutter is required for a train wheel, some difficulty will be found in making one so that both sides of the teeth are rounded alike, unless some special tool is made to ensure this; if only one or two wheels are to be cut, the following plan will give very good results with but little trouble.

A piece of steel having been fitted to the cutter spindle, as described before, a centre is formed at each end; fix a ferrule on it, and turn the end that is to form the cutter like a conical point of rather large size; making the pivot to just fill the space between two teeth of wheel of the size you require. The pivot is polished carefully, and then a flat is filed down to the centre, leaving just half of the pivot—it will then be exactly like a half-round bit in section; it is hardened, tempered, polished on the flat, the end stoned off square almost, and that also polished. In making a cutter on this plan, the sides are of necessity exactly alike; the only disadvantage is that as it is sharpened by polishing the flat face only, it gradually gets smaller after being sharpened a few times.

The parts most frequently found to require repair in the striking trains of clocks, are the pivots of the upper pinions, especially those of the fly, pin wheel, and pallet wheel. If the points are only slightly cut, they can be returned and polished, and a new hole put in; but if to entirely remove the marks the pivot would have to be much reduced in diameter, a new pivot is the only resource.

In putting in new pivots, the best way of centring the arbor is to put a lantern runner in the throw, having a hole large enough to take the sloped-off shoulder in the arbor; then the arbor can be centred with the graver, and the drill started perfectly true. A short stiff drill should be used (fitted to a plain runner in the throw), ground to cut in one direction only, rather thin at the point, and quite parallel for a short distance behind the cutting angles. The drill should be left quite hard, or, if a soft arbor is to be drilled, it may be tempered to a light straw colour, and the rest of the shank rather softer. If this is lubricated with either turpentine or benzine, but little difficulty will be found in drilling the arbor; the hole should be rather deeper than the pivot

is long, and in size rather larger than the pivot is to be. A piece of staff steel is now centred, hardened, blazed off, turned down true to fit the hole, and very slightly tapered (if too taper, the arbor will be split in driving it in); when it fits half-way in, draw-file it carefully, and cut it to length, filing the outer end off square. A few blows of a light hammer will fix it firmly in position; then the extreme end of the pivot can be turned to a centre, through a hole in the lantern runner. The pivot can now be turned down to size, polished, burnished, and the end rounded up. There are several tools sold for centring arbors for drilling, but there is no more accurate way than that described; as, if the hole should get out of truth in drilling, subsequent returning of the centre on the pivot end after it is inserted, corrects this. Should the pallet-wheel front pivot require repairing, a centre will have to be cut with the graver in the end of the square (as usually it is finished off almost flat at the end); then a male centre can be used, and the pivot turned and polished in the usual manner. This pivot is nearly always the first to show signs of wear, owing to the great strain on its locking, particularly in weight clocks.

In many old clocks, particularly in long-case striking clocks, the rack and gathering pallet are frequently found in very bad condition; the pallet perhaps fitting the square very badly, thus making its depth with the rack very uncertain. To make a new pallet is anything but a difficult matter; yet one seldom sees one properly made by the clock jobber. Frequently pallets are made of brass, a most unsuitable material for this purpose for English clocks, where the pallet not only has to gather up the rack, but also to stop the train at the conclusion of the striking. If the rack depth is planted as deep as it ought to be, there is not room for a very stout boss to the pallet, and nothing softer than steel should be used for this purpose in good work. In the absence of a proper forging, a pallet may be made from a square bar of steel, thick enough to give the requisite length of boss. Mark the length of the tail of the pallet, and file it down to almost the required thickness; file also the opposite face of the bar smooth and flat. Mark the position of the hole, and drill it at right angles to the face; the diameter of the hole will be the same as the small end of the square on the pallet pinion—measuring across the flats, of course. Start the corners of the square in the position you require them with a good square file; then take a piece of broken square file of rather a coarse cut, and of the same taper as the square on the pinion; oil it, and drive it in with a few light blows of a hammer, turn the pallet over and knock it out again, turning it a quarter round each time you withdraw it. In a few minutes you can thus form a good square straight hole, and fit it accurately to pinion-square. Put it on an arbor, and turn the ends square and to length, see that the tail is at right angles to the hole, also file the boss to form and shape the lip. This is usually made straight and the back sloped off; consequently it scrapes the rack teeth with its extreme end only, and wears quickly. As the pallet is in reality a pinion with only one leaf, its durability is increased by curving the face similar to a pinion leaf cut in half. The end of the tail of the pallet should be rounded and finished off smoothly at right angles to its face, its length such that it is well free of the pin in the rack when gathering the last tooth but one, and rests fairly on the pin when the rack is up.

If the tail of the pallet were left quite straight, and the end filed off square, there would be danger of the rack being held up by the pallet, particularly when the pin in the rack is planted lower down than it should be, its proper position being rather above the top of the teeth. The tail of the pallet is therefore curved to just throw the rack off.

If any of the rack teeth are damaged at the points, it may be necessary to slightly top all the teeth and file them

up again; only the backs, or curved sides of the teeth, should be filed, finally taking the burr off with the oilstone slip. In order to make the depth correct again, the rack arm is carefully hammered a little, to stretch it; great care must be taken to keep the teeth truly in circle, also to see that they are well free of the boss of gathering pallet —not only when it is in position resting on the rack pin, but also when it has moved into the position that it would be in when the clock has warned. If the boss of the pallet is not perfectly concentric, it may be just foul of the rack teeth in this position, although free when tried with the pallet resting on the stop pin. Sometimes this fault occurs in clocks that have been recently repaired, and, unless you suspect it, it is rather liable to escape detection, as workmen divide the run differently. Apparently, some consider this a matter of no importance, as you sometimes meet with clocks in which the hammer begins to lift as the clock warns, and a lot of useless run after the hammer has fallen. This is just the reverse of what should be the case, as the more run you get before the hammer begins to lift, the less probability there will be of the clock failing to strike when the oil gets thick.

A frequent source of trouble in some old clocks is the spring tail to the rack; it is intended to allow the hands to set forward without allowing the clock to strike. If the spring is weak and the rack spring strong, it sometimes gives a little and allows the rack to fall lower than it should, consequently a wrong hour is struck; an excess of end-shake to the hour wheel will also cause this fault, if the snail is mounted on the hour-wheel pipe. This is of course easily corrected by a thicker collet in front of the minute hand.

Another part that in ordinary clocks gets but little attention paid to it is the suspension spring for the pendulum. Any old piece of spring is generally considered good enough to make a suspension spring from, and the consequence is that one seldom meets with a spring that does not wind or twist more or less, it being almost impossible to straighten a curved piece of spring and keep it quite flat. If you wish to have the best material for this purpose, get some straight lengths of steel from the mainspring maker, of various thicknesses, and keep it for that purpose; they cost but little, and save time in grinding down, straightening, &c. The chops at the top of the spring are usually made by cutting a slit in a piece of brass of suitable thickness, and closing the slit down with the hammer upon the spring until it fits it.

A much better plan is to make the chops of 2 pieces of brass, and rivet them together with 4 rivets; the bottom edges should be slightly rounded off to prevent any chance of the spring breaking at that point, as it sometimes does if the edges are left sharp.

With regard to the strength of the spring, very few are met with that are too thin; but many err in the opposite direction, and are very much too thick. It is not always advisable to substitute a much thinner spring—especially should there be but little room for the pendulum to vibrate in, as sometimes the arc is so much increased as to cause the pendulum to strike the sides of the case, rendering it necessary to substitute a lighter weight or a weaker spring. The slit in the top of the pendulum is usually cut with a thin saw, and then closed with the hammer; but there is no certainty of keeping it straight this way, and it takes but little more time to file a true slot and fit a slip of brass to fill it up to the proper size, thus keeping the spring true with the rod.

For making new holes in the plates of clocks, many workmen use a punch which is more fit for a blacksmith, and hammer the plates about to close the holes which are worn. Instead of bruising the plates with such an instrument, why not go the right way to work, thus: cut off a piece of hollow brass wire (after it has been filed true and slightly tapering), open the hole so that the wire can be driven tightly in; if you cut it off the proper length so that

it just goes through the plate, it is very little trouble to reknit in, and when the job is done, and properly chamfered, it looks neat, and is in every respect better than a hole which has been knocked out of the round, and often out of depths. With this little matter, the first trouble is the best, for even if the knocking or punching job does answer for a time, it soon gets worn again. This method is preferable for English, French, and American clocks. One way of putting teeth into wheels is to make a hole through the plate of the wheel immediately below the point from which the tooth has been broken. Let its diameter be a little greater than the width of a tooth. Next, with your tooth-saw, cut down where the tooth should stand till you come into the hole. You then dress out, with a head upon it, a piece of brass wire, till it fits nicely into the cut of the saw, with its head in the hole. With a fine graver you then cut a crease into the wheel plate above and below, on either side of the newly fitted wire; after which, with your hammer, you cautiously spread the face of the wire until it fills the creases, and is securely clinched or riveted into the wheel. This makes a strong job, and one that dresses up to look as well as any other.

The collet in front of the hands is a little thing, but it is seldom right; one that will hold the hands firm, and allow them to be moved small portions of space with ease and certainty. Before making a collet, first straighten the minute spring, and put it on its place on the centre pinion. Put the minute wheel on its place on the top of it, and then the minute hand on its place; now see the space there is from the surface of the hand to the pin hole in the centre pinion. Make the collet so high that it will just cover the hole, and then cut a slit in the collet just as deep as the hole is wide. Make the slit to correspond with the hole in every way, and in such a manner that when the pin is put in it will fit without shake. A collet made in this manner will last as long as the clock, and when the minute spring is set up the hands will always be firm, and at the same time move easily, and not affect the motion of the clock when they are set backward or forward. The square on the pipe of the minute wheel sometimes projects through the minute hand, and the collet presses on it in place of the hand. When this is the case it should be filed down, because the minute hand cannot be held firm unless the collet be very much hollowed at the back, which it is not always advisable to do.

The suspension of the pendulum, the pendulum spring, and the action of the crutch, or back fork, on the pendulum, are all of the most vital importance. The spring should be perfectly straight, and should fit into the slit of the cock without shake, and the slit should be perfectly straight, and at right angles to the dial of the clock. The back fork should fit easily and without shake, and the acting part stand at right angles to the frames. The pendulum bob should swing exactly in a plane with the frames and the dial. After a clock has been put in its case, before putting on the head, it is well to get up high enough and look down to see that all these parts work as has been described. Before taking the movement out of the case, it is advisable to see whether you can find out the immediate cause of stopping. The points to which to direct attention are: The hands, to see if they are in any way bound; the catgut lines, to which the weights are attached; the striking parts, to see if there is any mishap connected with them; and the pendulum, to see if it is free. If all these things are correct, and the clock appears dirty, conclude it wants cleaning, or that it needs some repairs which will necessitate its coming to pieces. Having satisfied yourself on these points, proceed to take off the 2 weights and the pendulum, and remove the movement to your workboard to undergo the requisite examination, cleaning, and repairs. Placing it, dial downwards, on the board, commence by unscrewing the screws by which the movement is fixed to the seat-board, and remove it. The bell-stud screw is now unturned, and the

bell, bell-stud, and screw are placed on the board; then the bridge or "cock" screws and the pallets are taken out, and the cock is screwed back in its place. The cock is replaced, so that you may turn the movement over without fear of scratching the back plate, and it is left on till the last thing before the actual cleaning commences. The clock is now turned over face upwards, the small pin that secures the hands is removed with the pliers, and the collet or washer and hands are taken off. Pull out the pins that hold the dial, and remove it.

The movement consists of 2 distinct sets of "trains" of wheels, set within 2 brass plates, which are kept the proper distance apart by turned pillars. These are riveted to the back plate by one end, while the other ends pass through holes in the corners of the top plate, and are there secured by pins. One train of wheels and pinions constitutes the "going" part of the machine, and the other, with the various appurtenances connected with it, the "striking" mechanism.

The going train comprises the first or great-wheel and barrel, upon which the line runs; the centre wheel and pinion; third wheel and pinion, and the escape wheel and pinion. The striking train comprises the striking great-wheel and barrel; pin wheel and pinion; gathering pallet, pinion, and wheel; warning wheel and pinion; and the fly and its pinion. The names of the other parts of the clock are the pallets and crutch; cock; pendulum; bell-stud and bell; motion-work, embracing the cannon pinion, minute wheel, hour wheel, and snail; the hammer and hammer spring; lifter; detent rack; rack spring; rack hook, and gathering pallet.

The parts of a wheel are the teeth, the rim, the crossings, and the collet, or piece of brass on which the wheel is riveted. The parts of a pinion are the leaves or teeth, the arbor or axle, and the pivots which run in the holes.

Having obtained a good general idea of the mechanism, proceed to take the clock to pieces. Remove the motion-work, and the various parts connected with the striking, which are under the dial; pull out the pins which hold the top plate on, take it off, and remove the wheels. Take off the hammer, tail spring, and the cock, and the clock will be ready for cleaning.

Cleaning.—Different workmen have different methods of cleaning a clock, each supposing his own to be best; the following will be found as good as any. Mix up some rotten-stone with any good oil, and with a stiff clock-brush rub thoroughly over every part until all tarnish is removed. In brushing the plates, the brush must take one direction only, namely, lengthways of the plate, so that the scratches may appear in straight lines, otherwise it will look bad when finished. Should there be any rust on any of the steel work, it must be removed with fine emery cloth, and then rotten-stoned. Remove as much as possible of the rotten-stone and oil with an old duster, finish with a clean brush wetted with turpentine, and wipe dry with a clean duster. In cleaning the wheels, &c., care must be taken not to bend the teeth, or any other delicate parts; and not to rub sufficiently hard and long in one place to take off the corners and destroy the proper shape. Take especial care to clean out the teeth of the wheels, the leaves of the pinion, and round the shoulders of the pivots. The holes in the plates must also be well cleaned out with thin strips of leather, holding the plates in the bench-vice. Wrap a duster round the part that goes in the vice, unless the jaws are provided with lead clamps, so as not to mark the plates.

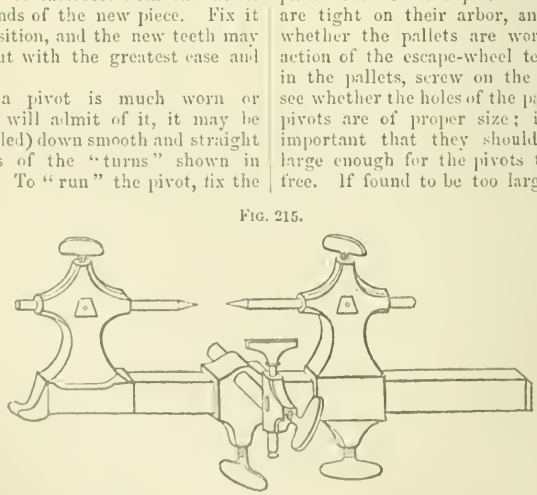
When every part is thoroughly clean, it will be ready for "examining," by means of taper iron pins, with a loop formed at one end, for affording facility in picking them up off the board, and about 2 in. in length. To make them, cut off the required number of pieces of iron wire, and form the loops at the ends; put them one at a time in the hand-vice, and, resting the free end upon the filing-block held in the bench-vice, file them to the proper taper. Keep turning the pin round towards you, but

only move it when the file is going in the opposite direction, that is, away from you. When filed to shape, they must be draw-filed with a smooth file, and finally burnished with a flat burnisher. A flat burnisher is simply a smooth piece of flat steel, and requires rubbing on the emery stick, so as to produce a grain crossways.

A much-recommended method of renewing wheel teeth is as follows: Proceed by fitting in a suitable piece of brass. Then procure a slip of zinc, drill a hole through it, and fit it tightly on the pinion or arbor on which the wheel is mounted. Secure it at a part where the teeth are sound, and cut it to the shape of the wheel; then with a slitting file or saw, cut out a pattern of 5 or 6 teeth more than you require in the new piece. When the zinc pattern is an exact copy of that part, bring it round to the new piece, allowing 2 or 3 of the zinc teeth to intersect with the wheel at both ends of the new piece. Fix it in this position, and the new teeth may then be cut with the greatest ease and accuracy.

When a pivot is much worn or cut, if it will admit of it, it may be "run" (filed) down smooth and straight by means of the "turns" shown in Fig. 215. To "run" the pivot, fix the

FIG. 215.



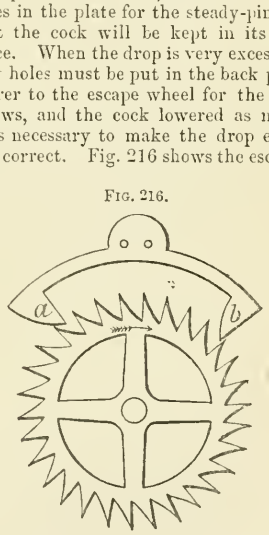
turns in the vice, and put in a female centre at one end, and a running centre at the other. Secure a screw ferule upon the sound end of the arbor, and, putting the point of the sound pivot in the female centre, adjust the position of the running centre, so that its groove receives the imperfect pivot, and allows it to have a good bearing. Put the gut of the cane bow round the ferule in such a manner that the downstroke may cause it to revolve towards you; then, placing the plain edge of a fine file against the shoulder, file down the pivot until quite smooth and straight, taking care that with every downstroke of the bow the file is pushed away from you, and at the upstroke drawn towards you. Lastly burnish with a flat burnisher.

In repairing the escapement, reduce the friction by making the acting faces of the pallets very smooth and of good shape, avoid all excessive drop and consequent loss of power, and render it as free as possible from liability to the variation of the motive force. To examine the escapement, place the third wheel and escape wheel in the plates, and pin together with the examining pins. See that the pallets and crutch are tight on their arbor, and observe whether the pallets are worn by the action of the escape-wheel teeth. Put in the pallets, screw on the cock, and see whether the holes of the pallet arbor pivots are of proper size; it is very important that they should be only large enough for the pivots to be just free. If found to be too large, remedy at once by putting new ones; return the pallets to their place again, and proceed to test the action of the escape wheels upon the pallets by pressing forward the third wheel with one hand, and confining the action of the pallets

by holding the crutch with the other, and then slowly moving it from side to side a sufficient distance to let each successive tooth "escape" the pallets. For the escapement to be correct, it should fulfil these conditions:—The drop-on to each pallet should be equal, and only sufficient to give safe clearance to the tooth at the back of the pallet from which it has dropped; there should be as little recoil as can be obtained from the shape of the escape wheel; the pallets should not scrape the back of the escape-wheel teeth; and the faces of the pallets should be perfectly smooth, and of such shape as to require to be moved by the escape wheel before "escaping" a sufficient distance to ensure a "good action" or movement of the pendulum. As a general rule it will be found sufficient if the end of the crutch moves about ½ in. from drop to drop of the wheel teeth. If the pallets are worn, the wearings must be filed out, at the same time taking advantage of the opportunity to make them a good shape.

The escape wheels should nearly fit the wheel, when pressed into it on either side, as far as it is possible for them to go, the great object being to have as little recoil as possible. The first thing to be done before taking out the wearings, or altering the shape of the pallets, is to "let down" the temper. This is done by heating them to a cherry red, and allowing them to gradually cool again. Having thus softened them, file the wearings nearly out with a rather fine file, and alter to proper shape. Then smooth-file them, and lastly, with a bell-metal or soft steel rubber and oilstone dust, finish them very smooth and free from file marks. They can now be hardened by heating to cherry redness and plunging into cold water, and afterwards tempered by warming till a part previously brightened with emery turns to a straw colour. If, upon trial, there is found to be too much "drop" off the outside pallet, on to the inside one, the pallets need "closing,' or bringing closer together, which is best effected by placing them upon the jaws of the vice, opened to a suitable distance, and giving them a tap with a small hammer, so as to bend them nearer to each other. Take great care in doing this, and see that the pallet arms have first been softened by heating as before directed, or they will break. If there is too much "drop" off the inside pallet on to the outside one, the pallets require bringing nearer the wheel. If the excess is not very great, it may be conveniently altered by lowering the cock a little. To do this, remove the steady-pins from the cock, and move it round so that the "drop" is corrected; then drill new holes in the plate for the steady-pins, so that the cock will be kept in its new place. When the drop is very excessive, new holes must be put in the back plate nearer to the escape wheel for the cock screws, and the cock lowered as much as is necessary to make the drop equal and correct. Fig. 216 shows the escape-

FIG. 216.



wheel and pallets. The arrow indicates the direction in which the escape wheel revolves: *a*, outside pallet; *b*, inside pallet. Though it is proper to leave as little "drop" as possible, do not carry this to extremes; but remember to give sufficient to ensure clearance after a little wear, and under disadvantageous circumstances, or else after going a few weeks, the pallets will catch, and the clock will stop. When the edge of the inside pallet catches upon a tooth, the pallets are too close to the wheel; when

the edge of the outside pallet catches, there is insufficient distance between the pallets. Some escape wheels are cut so irregularly that it is impossible to get a good escapement.

The opening in the crutch should be sufficiently large for the pendulum rod to move freely, with a little side-shake and no more; if at all rough inside, it must be made smooth and burnished, and then closed in to the proper size. See that the pendulum is sound everywhere; that the spring is not cracked or crippled; that the regulating nut and screw at the bottom act properly, and the bob slides easily on the rod. See also that its suspension is sound: it should rest well on the stud, and fit sufficiently tight as not to move at the top above the slit when swinging.

The striking train is generally examined before taking to pieces in a less critical manner; it is seldom so bad as to fail in striking, there being no resistance for the striking weight to overcome except the tension of the hammer tail-spring and rack spring, and the inertia of the train wheels. Should it be thought necessary, however, to be more careful, the course of procedure would be exactly similar to that described for the going train. The examination of the dial work is usually left until the clock is put together, as any errors can be easily altered, without in any way interfering with the rest of the clock. The plates are next carefully wiped with a clean duster; a leather strip is passed through the holes, and the wheels, pinions, and other parts are brushed clean, ready for putting together.

Putting Together.—Commence by screwing on the hammer spring and the cock. The cock is put on in order to allow the pivots to go through the holes until the shoulders rest on the plates, as the wheels do not fall about so much then as they otherwise would, and also to prevent the back plate being scratched by the workboard. Place the lower part of the plate towards you, and put the wheels, &c., in their proper places in the following order:—Centre wheel, third wheel, two great wheels, hammer, pin wheel, escape wheel, gathering-pallet wheel, warning wheel, and last, the fly. Take care to have the catgut lines running the proper side of the legs or pillars. If there is an arbor for a "strike or silent" arrangement, put it in now. When these parts are in their proper positions, carefully put on the top plate, and, pressing it moderately tight, guide the pivots into their respective holes, starting from the lower part of the frame. It is sometimes a great assistance to put the point of an examining pin into the holes of the lower pillars, when the top plate is on sufficiently far, as you have only then to attend to the top part. For the clock to look well when finished, there must be no finger marks upon any part; to avoid which, hold the plates, &c., with a clean duster when putting together, and keep it as bright as possible. When each pivot is in its place, and the top plate is resting fairly on the shoulders of the pillars, pin up with the examining pins, and test the correctness of the relative positions of the wheels.

There cannot, very well, be any mistake with the "going" train, but it is advisable just to press round the great wheel a turn or so, and see that all runs freely. The wheels of the striking train, however, require to be placed in certain arbitrary positions in regard to each other, except the great wheel and fly, which are exempt. The first position to be tested is that existing between the pin wheel and the gathering-pallet pinion. In order to do this, put on temporarily the rack, rack spring, hook, and gathering pallet. Let the rack hook hold the rack gathered up, with the exception of one tooth, and move round the pin wheel very slowly until the hammer tail just drops off; at that instant the tail of the gathering pallet should have about $\frac{1}{4}$ in. from the pin in the rack which stops the striking. If there is an excess of this, or if the hammer tail is resting on a pin, the top plate must be slightly raised, and the pin wheel moved a tooth farther on in the pinion until it is as near this condition as possible. The reason for

making the striking chain cease running, as soon as can safely be done after the hammer falls, is that there may be as much run as possible before it has to raise the hammer and overcome the tension of the hammer spring. Under no circumstances leave the hammer tail "on the rise"—that is, resting on one of the pins of the pin wheel—when finished striking.

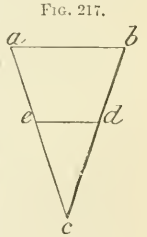
Having adjusted this, see that "the run" of the warning wheel is right. Put on the lifter, and gradually raise it till the rack hook liberates the train, and "warns." The distance the warning pin should run is half a turn, so that immediately before it "warns" it should be exactly opposite the piece on the detent, against which it is stopped, until the lifter falls and the clock strikes. See that the warning pin catches fairly on the stop-piece of the detent; if it does not, it is because the rack hook is raised either too soon or too late by the detent: alter as may be necessary. When the train is quite correct, remove the rack, &c., and pin up the plates finally with good-shaped pins.

It matters little what care may be bestowed upon repairing and cleaning if the clock is badly pinned up, for no certainty of performance can be expected in such a case. Therefore make a proper shaped pin, not too thorny nor too straight, but gradually tapering, round and smooth, and well fitting the hole it is intended to occupy; then drive it in tight, and cut off at an equal length each side of the hole. The front plate will now be ready for oiling.

To make an "oiler," file up a piece of iron wire something like an examining pin, but about 4 in. long, and then flatten out the end like a drill. A very good oil for house clocks is olive oil. Pour some into some small vessel, and with the point of the oiler proceed to oil the pivots of the front plate by putting a little into each sink. A very little is sufficient, or it will flow over, and run down the plates, giving a very bad appearance. Slightly oil the studs upon which the rack and other parts work. The cannon-pinion spring may now be put on the centre arbor, and the cannon pinion and minute wheel in their places. They must work together in such a manner that the lifter falls exactly when the minute hand is upright; put the minute hand on the square of the cannon pinion, and see that it does so, or move the cannon pinion a few teeth in the minute wheel until right. The remainder of the dial work may now be put on, and the only items to observe are that the hour wheel works into the minute-wheel pinion, so that the hour hand is in its proper position when the clock strikes, and that the proportions and fall of the rack are correct. These are very important matters, and must be left exactly right, or the clock will be continually striking wrong.

Few clock repairers understand the proportion which should exist between the rack and rack tail. Fig. 217 will probably make the matter quite plain. To test the rack in its place, allow it to fall until the tail rests on the lowest step of the snail; the rack hook should then hold the rack, so that there are 12 teeth to be gathered up; then try it on the highest step—it should now exactly fit in the first rack tooth, leaving only that one to be gathered up. Supposing the clock strikes 13 when on the lowest step and 2 when on the highest, it shows that the end of the rack tail is a little too far off from the snail, and must accordingly be set a little closer. If, however, it strikes the right number when on the lowest step, and 2 when on the highest, then the proportion between the rack and rack tail is wrong; the rack tail travel being too great for the rack. To make the matter plain, suppose that we have to make a new rack tail, which is often necessary in badly used clocks. Measure first with a pair of spring dividers

Fig. 217.



the proper distance that the rack teeth fall for 12 to be struck by the clock, and mark that distance on a piece of paper, as shown *b* to *a*; then take the distance from the points of the rack teeth to the centre of the stud, upon which the rack works, and mark that as shown *b* to *c*; then from *a* draw a straight line to *c*. Take the total distance the rack tail has to fall—viz. from the top step of the snail to the lowest, and from where the 2 lines, *a c* and *b c*, are that distance apart, to the point, *c*, is the length required for the new rack tail. In the diagram, the distance from the highest to the lowest step of the snail is supposed to be from *c* to *d*, therefore the length of the rack tail would be from *d* to *c*. When all is set right, pin on the dial, and put on the hands. There should be sufficient tension in the spring for the hands to move tolerably tight, or they will stop when the minute wheel has to raise the lifter. It is always best to use a steel pin to hold the hands on.

The clock is now turned over, and the pallets are put in. It is necessary to put a very little oil on the pallets where they touch the escape-wheel teeth, the pins of pin wheel, acting portions of the hammer spring, and crutch. See that the hammer acts properly on the bell; screw on the seat-board, and oil the pulleys.

Finally, put up the clock in the case. Fix the case as firm as circumstances will admit, then see that the seat-board has a good bearing, that the dial is upright and does not lean either backward or forward, and that the crutch is free of the back of the case. Hang on the weights, and wind them up carefully, observing that the lines run properly on the barrels. It sometimes happens that the line is longer than sufficient to fill the barrel, and, instead of forming a second layer across the barrel, rises perpendicularly, until it interferes with the clockwork. The best way to rectify this error is to put a piece of wire across the hole in the seat-board in such a manner as to throw it off as desired. Put on the pendulum, and set the clock "in beat." The meaning of "in beat" is, that the escape takes place at equal distances each side of the pendulum's centre of gravity. When the pendulum is at rest, it should require to be moved as much to the right before you hear the "tick" as it does to the left, and *vice versâ*. When "in beat" it sounds regular, and nearly equal, the differences of drop making it slightly uneven. The general rule for setting in beat is this:—If the right-hand beat of the pendulum comes too quick, the bottom of the crutch requires bending to the right; if the left-hand beat comes too quick, then the crutch must be bent towards the left. The clock may now be considered finished. Regulation is effected by raising the pendulum bob to make the clock go faster, and lowering it to make it go slower.

30-hour English Clocks.—The manufacture of these clocks has entirely ceased; there are still a large number in use, however, which occasionally require cleaning and repairing. Two styles are met with: in one, the wheels are set within a square frame formed of several pieces, and known as "the birdcage"; in the other, the wheels are between 2 plates similar to the 8-day. There are 2 points of difference which require attention—the endless chain, and the striking mechanism. The endless chain must be put upon the spiked pulleys in such a manner that the wheels turn the right way when the weight is put on, and the part that requires pulling to raise the weight should always come to the front, so that the weight passes quite free behind it, Fig. 218. Sometimes the chains will be found to be twisted, and the links, gathering up into a knot, stop the clock. The way to rectify this is to draw up the weight, separate the chain at the lowest part, let it hang free, straighten both pieces, and then unite again, when it will be found to work properly. A leaden ring, of sufficient weight to keep the chain just tight, is used to prevent the liability to twist. When a chain breaks from wear

or rust, or jumps from being the wrong size, it becomes necessary to put a new one. They are made from iron wire.

The most common kind of striking mechanism in 30-hour clocks is known as the "locking plate," and though it is more liable to derangement than the rack movement, still it is very largely used in French, American, and German clocks. It is much more simple than the rack, and one explanation of its construction will be sufficient for every case. The various parts are shown in Figs. 219 and 220: *a*, hoop wheel; *b*, lifter; *c*, hoop-wheel detent; *d*, warning detent; *e*, locking plate; *f*, locking-plate detent; *g*, lifting pin to raise hoop-wheel detent; *h*, spring; *i*, warning pin. In testing the relative positions of the striking wheels when put together, proceed by moving the wheels round very slowly until the hammer tail drops off a pin; at that moment the hoop-wheel detent should fall into the hoop, so as to allow the hoop wheel about $\frac{1}{4}$ in. run before it reaches the end of the detent and stops the striking. When the hoop is resting against the detent, the warning pin should have half a turn to run, the same as in the 8-day clock. The locking-plate detent *f* is connected by an arbor with the hoop-wheel detent *c*, and must be adjusted so that the latter can fall in the hoop wheel sufficiently far to stop the striking only when the end of the locking-plate detent falls into one of the notches of the locking plate. This is easily done by moving round the wheel to which the locking plate is attached, a tooth at a time, in the pinion that drives it, until it is in the correct position, and slightly bending the detent *f*, if necessary. When a clock with a locking-plate striking arrangement strikes till it runs right down, it is generally because the hoop-wheel detent does not fall freely, or the locking-plate detent does not enter the notches properly. It sometimes happens that the edge of the end of the hoop becomes worn and rounded by long use, and if the weight is excessive, it will cause the detent to jump out, and the clock to continue striking until run down. The remedy is obvious—file the end square. The locking plates are often cut irregularly; but on no account interfere by filing or spreading the edges, or perchance greater difficulties may arise, and there is always a position where it will answer well, which can easily be found by trial.

FIG. 218.

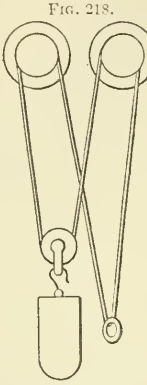


FIG. 219.

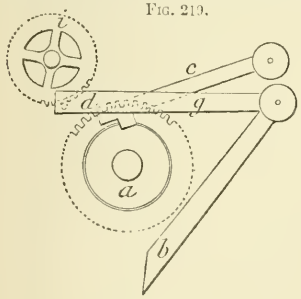
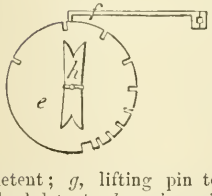


FIG. 220.



Spring Clocks.—The motive power of these timepieces being produced by the uncoiling of a spring, several parts are introduced which are not found in weight clocks—namely, the spring barrel, fusee, and stopwork. The cover of the barrel ought always to be removed when cleaning the clock, to ascertain the condition of the mainspring, and, if the latter is found at all

dirty, it should be carefully removed with a pair of pliers, and cleaned with a little turpentine on a piece of rag. It may be replaced by winding it round its own arbor, which should be screwed in the vice by the squared end. Take hold of the end of the spring with a pair of strong pliers, and wind it as tight as possible; then slip the barrel over it, and carefully let go the spring, holding the barrel tight with the left hand until the spring has hooked. To try that it has hooked securely, before putting it back in the clock, put on the cover, secure the end of the arbor in the vice, and turn round the barrel until you can feel the spring is quite up. A new spring can be put in in the same manner. Always oil the main-spring after it has been handled. When a new barrel hook is required, select a piece of good steel, and file up a square pivot with a nicely fitting shoulder, and fit in the hole in the barrel; then shape the hook, and rivet in its place.

The fusee is liable to accidents to the clockwork, and when a chain is used, to breakage of the chain hook-pin. There are 2 kinds of line used to connect the fusee with the barrel—catgut and metallic. Metallic lines wear better, look better, and are quite as cheap as gut. To ascertain the length required for a new line, fix one end in the fusee, and wind the line round in the groove till it is filled up; then allow a sufficient length beyond to go round the spring barrel 1¼ turn. When catgut lines are used, they should be slightly oiled. The method of fastening the ends is so simple as to need but little description. The fusee end is passed through the hole in the fusee, and tied in a simple knot, the end being slightly singed to render it less liable to slip. The barrel end is passed through the holes in the barrel in the following manner:—Down through the first hole, up through the second, and down through the third; the end is then pushed through the loop formed by passing the line through the first and second holes.

Take special care, in putting together, to see that the line is free, and on the right side of the pillars. When ready to put the line on in its place, wind it upon the spring barrel by turning the arbor; and when it is all on, and the fusee pulled round as far as it will go, set up the spring one turn, and secure the click in the ratchet. Wind the clock up, carefully guiding the line on the fusee, and see that the stopwork acts properly, and does not cut the line when it rubs against it. The snail in the fusee should catch against the stop directly the fusee grooves are filled up with the line.

Musical Clocks.—These call for no special remarks, beyond that it is advisable to well understand the action of the "letting off" work, and the "run" allowed, before taking to pieces. The arrangements are so different that scarcely 2 are exactly alike; but they seldom offer any great difficulty when ordinary care is taken. It is wise in some cases to keep the striking and chime parts distinct while cleaning. Most of these clocks present favourable points for improvement by reducing the friction, and, when it can be safely done, it is well to do it; for, though the weights are unusually heavy, there is generally no power to spare.

Outdoor Clocks.—In the case of large clocks, the cause of stopping is usually apparent, and by trying the side-shake of the pivots in their holes, it can be readily seen if any new ones are required. The depths are nearly always correct, and the end-shakes can be tried the last thing when put together. There are 2 ways of treating such clocks: one consists of cleaning them as well as it is possible with emery cloth, and turpentine upon a brush, without removing any of the wheels from the frame, called "wiping out"; the other, in taking them all to pieces and thoroughly cleaning, in the same manner as small clocks. Which method is necessary or desirable must be decided by judgment. It will be found usually sufficient to thoroughly clean them about every 5 or 6 years, and "wipe them out" once every year—about autumn being the

best time, before the cold weather sets in to influence the oil.

If the clock drives one or more pairs of hands, it is very necessary to see that the leading-off rods and universal joints do not bind in any part of their movement. When the dial work stands in a very oblique position in regard to the driving wheel of the train, it is often much better to use bevelled wheels than the ordinary leading-off rods and universal joints, and small-sized straight-drawn iron gas-tubes will be found very serviceable for making the connections, by simply fitting turned pieces of steel into the ends, to carry the wheels.

After a new hemp line has been put to a turret clock, if continued wet weather follows, it will oftentimes be found to twist and gather round so much as to stop the clock. The way to remedy this is to take the weight off, straighten out the line, and then replace it, giving it a few turns in the opposite direction to its twist. If this fails, as it sometimes does, the following plan will be successful:—Mix together about ½ lb. soft soap and a packet of blacklead until incorporated, and work it well into the rope along its entire length, laying it out in one long straight line, and quite free to turn during the operation. It is rather a dirty job, but very efficacious, and well repays the trouble when hemp ropes are used; it hardens the rope, making it last longer and work better.

Drum Timepieces.—These seldom go satisfactorily for any length of time with the treatment they ordinarily receive. In addition to the usual careful examination of depths, end-shakes, sizes of holes, &c., it is necessary to bear in mind the following principal causes of their bad performance—defective calibre, roughness of finish, and faulty escapements. Defective calibre is unalterable, for you cannot prudently make any useful alteration in the proportions of the various parts, as the expense would probably be more than the timepiece would be worth. There is, however, one very important part which demands attention, and that is the mainspring. This usually has to make such a large number of turns for the timepiece to go the prescribed 8 days that considerable skill is required to make an escapement which will give a fairly uniform rate. Therefore it is always desirable to have a thin mainspring, in order to obtain as many turns as the size of the barrel will admit.

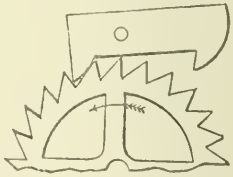
Rough finish must be remedied, especially in the parts farthest from the motive force. To this end, thin down the third, fourth, and escape wheels, when found unnecessarily thick, by filing with a fine-cut file, and finish smooth with a piece of water-of-Ayr stone. Take care not to raise a "burr" by using too coarse a file, and look out for imperfections in the teeth. If the pivots of the escape pinion and pallet arbor are left any too large, reduce their size by "running" in the turns, and burnish them well.

In these timepieces, faulty escapements are almost invariably found, and may be considered their greatest defect. With the object of rendering the pendulum insensitive to the varying power of the mainspring, the pallets are made as close to the arbor as possible, embracing only 1 or 2 teeth of the escape wheel. The inside pallet communicates impulse to the pendulum, but the outside one, forming part of a circle struck from the centre of motion, gives no appreciable impulse, as the escape-wheel teeth merely rest "dead" on it. Unfortunately, this principle is carried too far, and the result is that at times there is insufficient force at the escape wheel with such a small amount of leverage to maintain the vibrations of the pendulum, and the timepiece stops. As no beneficial alteration of the original pallets can be made in a proper workmanlike manner, it is best at once to condemn them, and make a new pair. By very carefully following the instructions here given, no great difficulty will be experienced in making them give favourable results. The object of making new pallets is to obtain a longer leverage, so that the occasional diminished force may prove sufficient to keep

the pendulum vibrating; and the difficulty which arises is to make them of such a shape that this varying power of the escape wheel does not influence the time of the pendulum's vibrations, however much it may the extent. The object is attained by making the pallets embrace a larger number of teeth, which brings them a greater distance from the centre of movement, and thus increases the leverage. The difficulty is overcome by making the pallets of such a shape that the escape-wheel teeth rest as "dead" as possible during the excursion of the pendulum beyond the distance necessary for the escape to take place. From a consideration of the shape of the escape-wheel teeth, and the distance the pallet arbor is pitched from the escape wheel, it will be readily seen that, though the outside pallet can be easily made to give the desired effect, it is impossible to make the inside one of any shape that will not produce more recoil than is desirable.

To render this recoil as insignificant as circumstances admit, great care must be bestowed in suiting the pallet to the wheel, and for the same purpose it is advisable to make it nearer than the outside one to the pallet arbor. Before making the new pallets, file off the old ones, guarding the pivot so that the file cannot slip and break it off, and leaving the arbor round, smooth, and slightly taper. Procure a small piece of card, and make a straight line down the centre; then, with a pair of compasses, take the distance from the escape-wheel pivot-hole to the pallet-arbor pivot-hole, and make 2 small holes through the card upon the straight line that distance apart. In one of these holes fit the escape-wheel arbor so that the wheel rests flat upon the card, and in the other fit the pallet arbor. The number of teeth most suitable for the new pallets to embrace must be decided by the character of the train; if it is fairly good, 4 will be found sufficient; if very rough, 5 had better be the number. Select a piece of good steel, of suitable thickness; having softened it, drill a hole through it, and fit the pallet arbor in to the proper distance. Put the escape-wheel arbor through one of the holes in the card, and the pallet arbor with the piece of steel on it in the other, and see how much requires filing off, so as to leave only sufficient to make the pallets of the proper length. Now mark off the position of the opening between the pallets, the distance of the inside pallet from the line of centres being equal to the space between 2 of the escape-wheel teeth, leaving the space between the points of 3 teeth on the opposite side of the line of centres. Fig. 221 shows the

FIG. 221.



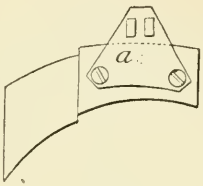
escapement. It is advisable not to file out the full width until the pallets are roughly shaped out and ready for escaping. They should be made of the shape shown, keeping them flat across the surface; and they may be roughly "scaped" for trial upon the card, which, by bending, can be made to move the pallets nearer or farther off as desired. When nearly right, finish the escaping in the frame, taking great care not to get too much drop on to the inside pallet, as there is no way of altering it should there be an excess. The drop on to the outside pallet is easily adjusted, as the hole in the front plate is in a movable piece, which can be turned with a screwdriver.

Respecting the shape of the inside pallet, it will be seen that its point resembles a half tooth of an ordinary wheel; this is to cause the friction and recoil, which are unavoidable, to take place, with the least impediment to the pendulum, as this shaped-point rolls upon the faces of the escape-wheel teeth, whilst the ordinary form scrapes them. When the pallets are properly "scaped,"

it only remains to finish their appearance in a workmanlike manner, and harden and temper them. The sides should be nicely "greyed" by rubbing them on a flat piece of steel with oil-stone-dust and oil, and the acting faces polished with diamantine or redstuff. It will be generally found sufficient to secure them by driving the pallet arbor in tight; but if thought necessary, they may be pinned on. The timepiece may then be cleaned and put together, observing that it is nicely "in beat," according to the conditions already stated.

When these drum timepiece movements are fitted into large gilt or bronze cases, where there is plenty of room for any motion the pendulum may take, it is a great improvement to suspend the pendulum with a spring, for the pallet-arbor pivots, being relieved of the dead weight of the pendulum, do not wear the holes so quickly, and, as the friction is considerably reduced, the pendulum is kept in motion with less power. The best way to put a spring suspension is as follows:—If there is sufficient substance in the cock above the pivot hole, drill a hole through the cock and tap in a piece of $\frac{3}{16}$-in. brass wire, with a slight shoulder, and rivet it in secure. Cut off so as to leave it about $\frac{1}{2}$ in. long, and make a saw-cut to receive the brass mount of the pendulum spring. The underneath part of this stud should be left nearly in a line with the centre of the pivot hole. When the pivot hole is too near the top edge of the cock to allow this to be done, a piece of brass must be fitted on to the cock to receive the stud; a very convenient shape is shown at *a* in Fig. 222. Procure one of the thinnest and most suitable French clock pendulum springs, fit one of the brass mounts into the saw-cut in the stud, and arrange it so that the spring, when in action, may bend as near as possible in a line with the centre of the pivot hole; then drill a hole through the stud and brass mount, and secure it with a pin. Fit a steel pin on which to hang the pendulum, in the hole through the other brass mount. The pendulum rod should be a piece of straight, small-size steel wire tapped with a thread at both ends. Make the hook exactly like the ordinary French clock pendulum

FIG. 222.



hooks, only very much smaller and lighter, and fit it on one end of the pendulum rod; screw the pendulum bob upon the other. Cut the old pendulum-rod in two, so that the piece remaining attached to the pallet arbor reaches to opposite the centre-wheel hole; file a short pivot on the end, and fit on it a crutch. All the parts must be as small and light as possible, and the pendulum bob must be round and turn tolerably tight. Silk suspensions are sometimes used, but rarely give satisfactory results, as they are so sensitive to atmospheric changes.

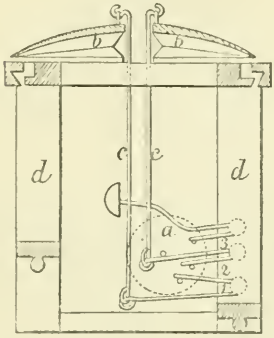
Bird Clocks.—These often give trouble from the bad mechanical arrangement of the parts. The great secret in repairing them is to reduce the friction as much as possible. The resistance to the rising of the "lifter" is often enormous, and may generally be reduced very much.

The mechanism of the cuckoo clock, as usually met with, is shown in Figs. 223 to 226. There are 3 distinct movements to be considered: (1) for the production of the sounds; (2) the appearance and retirement of the bird; (3) the movement of the wings and beak.

Fig. 223 shows the first. The dotted circle *a* represents the position of the pin wheel set within the frame, the pins of which have to raise 3 levers. Those numbered 1 and 2 raise the bellows *b*, and 3 corresponds to the ordinary hammer tail. The bellows are connected with 2 small "stopped"

organ pipes *d*, measuring externally about 6 in. long and 1 in. square; and the "stops" are pushed in till the right note is obtained. The bellows are

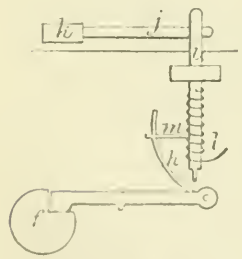
FIG. 223.



about 2½ in. long by 1½ in. wide, and are connected with the lifting levers by the wires *c*.

Fig. 224 shows the second movement:—*f* is the hoop wheel, and *g* the detent, which, falling in the notch,

FIG. 224.



stops the running of the striking train. *h* is a wire lever attached to the arbor of the detent, and moves with it. *i* is a vertical arbor carrying a piece *j* at right angles, on which is fixed the bird on the perch *k*. A spiral spring *l* keeps the short lever *m* in proper position, to be acted upon by the long lever *h*. As shown in the sketch, the cuckoo would be in; when the clock strikes, the detent *g* rises to the edge of the hoop wheel, moving the vertical arbor *i* with it, and the cuckoo on the perch *k* opens the door by means of a wire link, which unites the perch with the door. The bird remains out until the locking-plate detent allows the detent *g* to again fall into the hoop wheel, when the spiral spring *l* causes the bird to retire and close the door.

Figs. 225, 226, show the mechanism of the cuckoo. The body of the bird is hollow, and *n* is a block of wood in the centre of the body, firmly fixed upon the perch *k*. A pin *o* passes through the bird and block of wood, and serves for an axis, upon which the bird works when the tail is raised. The lower part of the beak is pivoted, and has a piece of wire attached; a wire projecting from the fixed wood block *n* terminates in a small ring which embraces the wire of the bill. When the tail is raised, the head lowers and the beak opens. The flapping of the wings *p* takes place in a somewhat similar manner; they are united to the body by wire-ring joints at *r*, and a short wire lever is fixed in the upper edge of the wings. The end of this lever is joined by a ring joint to a fixed wire on the block. When the

FIG. 226.

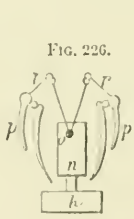
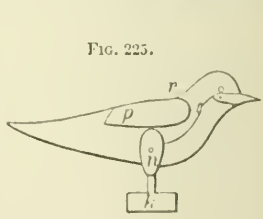


FIG. 225.



tail is raised, and the body moves farther from the centre of motion, the wings open; when the tail is lowered, they close. A piece of wire, fixed in the tail, is bent until exactly over one of the bellows. When the bellows are raised, they lift the wire of the tail, and thus cause the beak to open and the wings to flap. In putting the train together, be careful to have neither of

the levers resting on the pins when finished striking; and make the other parts work easily.

German Clocks.—When of the ordinary construction, these call for no especial remarks; the principal point to notice is the back hole of the pallet arbor, which will be generally found much too large. It is an easy matter to put a new one.

American Clocks.—Try the pinions to see if they are tight on the arbors, for they are often loose. The best way to secure them is with a little soft solder, taking great care afterwards to thoroughly clean off all the "tinning" fluid with chalk and water; finally oil them slightly all over. When the pendulum wabbles, it is owing to the spring being crippled, or loose in the stud, or to want of proper freedom in the crutch. One authority remarks that when the pinions of American clocks are worn, the quickest way to remedy them is to carefully turn each wire round, then add a small piece of solder to each; use rosin instead of salts for the soldering, then there will be no fear of the pinion turning rusty. This method, in some respects, is preferable to putting new wires; as, if a novice does the job, he is liable to push in wire that is much thicker than is required, which, of course, causes a bad depth. When American pallets are worn, the simplest way to move them is to get the centre of a Geneva hand and put behind the pallets, which will, in most cases, move them sufficient for them to act on an entirely new part. When the brass holes get worn, it will sometimes be well to open them, and solder in a piece of hollow brass wire; then open the wire to fit the verge pin. This is better than wasting time trying to close the old brass holes.

French Clocks.—The cleaning and management of these clocks is simple. It occasionally occurs in new clocks, that a movement has been fitted to a case that is not high enough to allow the pendulum to swing free when the clock is regulated to the proper time. Sometimes filing a little off the bevelled edges of the ball will allow the pendulum to clear the bottom of the case or stand of the clock, and allow it to be brought to time. Should more than a little be required taken off the edge of the ball, there is no use troubling with it further. Either get a new movement, or alter the train, or make a new pendulum ball of a peculiar shape. The train is easiest altered by putting in a new escape-wheel pinion containing one leaf less than the old one. In all cases, where pinion wire can be had, putting in a new pinion is not much trouble; but if this cannot be done, and a new movement cannot be had, a new pendulum ball of an oblong shape may be used.

As soon as new clocks are unpacked, whether they appear in good condition or not, it is always well to take the movements to pieces, and to examine every action in the clock. Begin by taking off the hands and the dial, first trying if the hands move freely. Then examine the drops of the escapement to see if they are equal; if not, they can easily be corrected by moving the front bush of the pallet arbor with the screw-driver, making a light mark across the bush with a sharp point, which will show how much the bush has been moved. The fly pitching may next be examined, and adjusted by the movable bush in the same way. The object of this bush being left movable is to admit of the depth being adjusted, so that the fly will make the least noise possible, and also to regulate the speed of the striking train. The dial work and the repeating work, if any, may now be removed, and the springs let down, the end and side shakes of the pivots in their holes carefully tried, and all the depths examined; as a general rule they will be found to be correct. The pivots will, in some instances, be a little rough, and it will not be much trouble to smooth them.

After examining the mainsprings, and noticing that the arbors are free in the barrels, the clock may be cleaned and put together. This will be most conveniently done by placing all the wheels first on the back plate, and putting the

front plate on the top. Get all the long pivots into their holes first, and as soon as possible put a pin into one of the bottom pillars. The locking of the striking work of these clocks is very simple, and all the pieces are marked.

Be sure that the arbors in the barrels are oiled, and that the mainsprings are hooked before you put them in the frame. See that there is oil on the pivots below the winding ratchets before they are put on, and that the wheel which carries the minute hand moves round the centre pinion with the proper tension, before you put on the dial. This cannot be remedied after the dial is put on, without taking it off again, and if the hands are loose, results fatal to the character of the clock are sure to follow.

To regulate the clock, it is safest to turn the case round, examine the regulator, and, if it is a Breguet, put a slight mark with a sharp point across the regulator. When the regulating square is turned, you will see exactly how much the regulator is altered; because there is sometimes a want of truth in the screw that moves the sliding piece, which deceives people as to the distance they may have moved the regulator. There are various kinds of regulators, but probably the Breguet is the most common of those of modern construction. Silken thread regulators should always be regulated with caution, and when small alterations have to be made, it is well to use an eye-glass and notice how much the pendulum is moved up or down. If a clock with such a regulator has to be moved or carried about, when it is out of the case, it is always best to mark the place where the pendulum worked in the back fork when it was regulated to time; for should the thread be disarranged, it can be adjusted so as to bring the mark on the pendulum to its proper place, and the regulation of the clock will not be lost thereby.

When fastening the clock in its case, put it in beat by moving the dial round a little till the beats become equal; but it sometimes occurs that when the clock is in beat, the dial is not square in the case. When this happens take the clock out of the case and bend the back fork at its neck till it moves exactly as far past the centre-wheel pivot on the one side as on the other, when the pallets allow the escape wheel to escape. If this is done, the dial will be square when the clock is in beat. Some French clocks have their back forks loose, or rather spring tight, on their arbors. This is sometimes done in movements that have plain as well as jewelled pallets. If the pallets are exposed in front of the dial, you can at once detect by the eye if the clock be out of beat; but if they are inside, you cannot tell without close listening. One of the objects of the loose crutch is that the clock can be put in beat by giving it a shake; but it is evident that if a shake puts it in beat, another shake will put it out of beat again. Great annoyances arise from these loose crutches; these ought always to be rigidly tight, except, perhaps, when the pallets are jewelled, or when the clock is not liable to be moved.

These clocks seldom require any repair, except perhaps the pallets get cut; but they are generally made so as to admit of the action being shifted, which is easily done. Cleaning the brass is done in the usual way. Buffs should be used for the large pieces, when very dirty; but if they are only slightly tarnished, a little potassium cyanide dissolved in alcohol will be found very suitable. The ornamental cases require to be handled with care, to prevent finger marks. In the highest priced clocks this precaution is perhaps not quite so necessary, because then the cases are either real bronze, or gilt and burnished; but in the cheaper qualities, and also in some expensive patterns of cases, the gilding is easily damaged. A little potassium cyanide and ammonia, dissolved in water, will often clean and restore it, if the gilding is not rubbed. There is a preparation sold in the form of a paste that renews the lustre of black marble cases if they have become dim. If the preparation cannot be got

conveniently, a little beeswax on a piece of flannel may replace it.

Watches.—In setting to work upon repairing a watch, it is of great importance to adopt a regular system in submitting it to examination, always following a certain order in dealing with the various parts. This will obviate the risk of omitting some parts altogether and inspecting other parts more than once. The work is performed with the aid of the following implements:—

The "workboard" should be made of well-seasoned wood, rather large than small, and securely fixed at a convenient height in a good position as regards the light. Along the front edge should be a strip or "bead" of wood standing up about $\frac{3}{8}$ in., and at the ends and back pieces 4–8 in., may form the border. Hooks and nails may be driven in these wide pieces for holding tools and other things. Those who have limited space use a portable tray, with a similar border, which can be placed upon any table when required. The principal point to be attended to is that there are no cracks or crevices of any kind.

The "verge stake" is a round piece of steel, with a small narrow slit in the centre, mounted in a brass block used for resting the brass collet of a verge upon, whilst the balance is riveted on.

The "pinion stake" is a piece of brass or steel, about 2 in. long, with a number of graduated holes drilled in it, used for resting pinions on, when the wheels need securing or mounting anew.

The "bumping-up stake" is a steel stake, either round, square, or triangular at one end and hollow at the other; the solid end being used for hammering work on, and the hollow end for resting wheels and balances on when the arms require slightly bending by a gentle tap with the hammer.

The "pin vice" is a miniature vice with a long tail, by means of which it may be easily twirled between the thumb and first and second fingers.

The "filing block" is a small piece of box-wood, used for resting wire upon whilst it is filed up into pins.

The "sliding tongs" is a tool somewhat resembling a stout pair of pliers with straight handles, having a slide upon them by which the jaws may be tightly closed.

The "chalk box" is a little box for holding a lump of chalk upon which to rub the brushes used in cleaning, to free them from grease and dirt. It may be made by nailing up a small box 3–4 in. square underneath the workboard, with a small piece of wood to prevent the chalk falling out in front; or by fixing a piece of wood from the right support to a place underneath the workboard, when the chalk will wedge itself sufficiently firm for the purpose.

The "mainspring winder" is a tool used for winding up a mainspring, so that it may be easily placed in the barrel.

A double-ended pair of brass callipers, with a small sink made in each end of one pair of arms; and a sink and a short male centre opposite, in the ends of the other pair of arms; they are used for testing the truth of wheels, balances, &c.

Of burnishers, one flat and one oval will be necessary for burnishing the pins which hold the frame together and other purposes.

Very diminutive screwdrivers, made of small steel wire and fitted into a brass wire handle, are used for turning jewel screws.

A small sewing-needle, fitted into a piece of brass wire for a handle, filed down very fine, and then slightly flattened at the point, so as to take up a very minute quantity of oil, is used for oiling the watch.

"Pivot broaches" are exceedingly fine taper pieces of steel—some round, others hexagonal—used for making pivot holes a little larger, or hardening the acting surface of them.

"Bottoming broaches" are small tools, something like the preceding, only that they are "4-square," and intended to cut only at the point or end.

A set of bench keys, or of variously

sized keys of the ordinary sort, bench vice, eye-glass, tweezers, watch pliers, nippers, screwdrivers, round and flat faced hammers, 2 brushes, oil-cup, knife, 2 or 3 files, covering glasses, French chalk, pegwood, tissue paper, pith, a cork or two, and 4 small examining pins, complete the equipment.

In examining a watch, take it in hand, and opening the bezel, attend to the following points before taking the movement out of the case. See that the enamel dial is not cracked or broken; that the hands fit properly, are of the right length, and quite free of the hole in the dial; that the cannon pinion is free of the glass, and that the seconds pivot is not too long and also free of the hole in the dial; that the joint pin fits tight; that the bolt and spring act correctly; that the cap is clear of the case when opening the movement, and comes freely from the frame when taken off; and that the winding-square is free of the case. Having done this, push out the joint pin, and carefully examine the movement as a whole. See that the wheels and the barrel are upright within the frame; that the wheels are free of each other, and of the frame or any part connected with it; that the chain is free of the pillar and the stop-stud; that the dial feet are not in the way; and that the dial, or brass-edge, as the case may be, fits properly against the pillar plate. By laying the nail on the surface of the glass, it will be easy to see whether there is sufficient freedom between the socket of the hand and the glass. In case of doubt, place a small piece of paper on the hand, close the bezel and tap the glass with the finger while the watch is in an inclined position: if free, the paper will be displaced. The dome must be at a sufficient distance from all parts of the movement, more especially the balance cock. If there is any occasion for doubt on this point, put a thin layer of rouge on the parts that are most prominent. Close the case, and, holding it in one hand to the ear, apply a pressure at all parts of the back with a finger of the other hand, listening attentively in order to ascertain whether the vibrations are interfered with. If the interval is insufficient, a trace of rouge will be found on the inside of the dome. In such a case, if the dome cannot be raised nor hollowed slightly in the mandril (when formed of metal), lower as far as possible the index work and the balance-cock wing, and fix in the plate, close to the balance, one or two screws with mushroom heads that will serve to raise the dome.

Verge Watch.—To take the movement to pieces, begin by detaching the hands with a pair of nippers (if it is carefully done, the hands will not be marked), then draw out the pins which hold the dial, and remove it. These pins are sometimes very troublesome to get out with the nippers or pliers, and are often best removed by pressing the edge of a knife into them close to the dial feet, and using the blade as a lever. The mainspring must now be "let down." Unscrew the click screw a little, place a fitting watch-key upon the barrel-arbor square, relieve the ratchet, and gradually let the spring down. Beginners should always make it a rule to let down the mainspring at the commencement, and if the watch has maintaining power, as most lever watches have, also to relieve the detent, for it is a very bad plan to let the train "run" down, and if by any chance the top plate is removed with the spring wound up, the effect would be probably most disastrous. The motion work, including the cannon pinion, being removed and the spring let down, proceed to unturn the cock screw, and take off the cock. The cock is the piece that receives the top pivot of the verge, staff, or cylinder. See that none of the screws overturn; it is important that all screws should be perfect in this respect. If any should overturn, make a note in pencil on the board paper so that it will not be forgotten.

Withdraw the pin that secures the balance spring to the stud, turn round the balance until the spring is free of the stud, and remove the balance. In

some watches, the curb pins will be found bent over to prevent the balance spring from escaping from between, or more than one coil getting in. In such cases, the balance spring must be freed from the curb pins as well as the stud before attempting to remove the balance. Proceed to take off the name-plate and regulator slide, push out the pillar pins, and remove the top plate, when the wheels may be removed from their positions, and the watch will then be "taken to pieces."

Clean the various parts before proceeding with the examination. Before beginning to brush, the oil and dirt must be wiped off the plates with a small piece of clean chamois leather. The wheels and pinions must be well brushed, and the leaves of the pinions thoroughly cleaned with a pointed piece of pegwood. A small piece of elder pith will be best adapted for cleaning the pivots.

When the dirt and oil are removed from every piece, and the pivot holes in the plates have been "pegged out" until the pegwood comes out quite clean, the movement is ready for further examination. See that the pillars are all tight in the frame, likewise the studs that secure the "brass-edge" to the frame when the dial is not pinned on direct. If either of the pillars is loose, pin on the top plate with 4 examining pins; then rest the end of the pillar to be tightened upon a filing block, and carefully rivet the pillar till it is quite firm. In a similar manner, the brass-edge pillars or studs may be tightened, removing the dial and pinning on the brass-edge to the pillar plate. If either of the pin holes is broken out, or the end of the pillar is broken off, it may be repaired in 2 ways. File off the broken end of the pillar till a little lower than the surface of the top plate, make a centre mark, and drill a deep hole with the largest drill it will safely bear; then solder in a piece of brass wire to form a new pillar end, in which the pin hole may be drilled. The other way is to use a smaller drill, and fit a screw in. Proceed to try if all the wheels are tight on their pinions. Hold the pinion firmly between the smooth jaws of an old pair of pliers (or preferably a brass or copper lined pair), and see that the wheel has no movement either backwards and forwards, or up and down. If a wheel is found to be loose, it must be secured at once. Place the arbor in one of the holes of a pinion stake, so that the pinion head rests firmly upon it, and, with a half-round punch and hammer, carefully rivet the pinion until the wheel is tight and runs true in flat.

Such wheels as are mounted upon brass collets, like the contrate wheel in the verge movement, and the escape wheel in the lever, require to be treated rather differently. The collet must rest firmly upon the jaws of a "pair of clams," the clams being held in the vice; then the brass rivet is slightly burred over. In the case of a lever escape-wheel, great care must be exercised, or the wheel will be found out of flat, and it will not admit of being made true by the ordinary method of "bumping." The best method of making it secure is to carefully fix the pinion arbor in the clams, and then use the sharp point of a needle as a punch, making 2 or 3 burrs on the rivet of the collet. By this means, the wheel is rarely thrown out of flat. Ordinary flat wheels are riveted as nearly true in flat as possible, and then, if necessary, "bumped"—that is, the wheel is set up between the ends of a pair of callipers, and by means of a little strip of brass—called a "toucher"—the crossings are found, which require bending to make the wheel run flat. It is then laid across the end of a bumping-up stake, and the necessary crossings are gently tapped with the hammer until the wheel runs true. The wheels must further be examined to see if any of the crossings are broken, or any of the teeth broken off or bent. If either of the crossings is broken, there is no good remedy but a new wheel; although sometimes, when the watch is an inferior article or old the crossing may be neatly soldered,

In a good watch, such a thing should not be countenanced. If a tooth is bent, it may frequently be raised to its proper position by the blade of a penknife, and sometimes by means of the tweezers.

To replace a broken tooth, a new tooth can be put in; it is never advisable to put in more than one tooth at the same part of the wheel. A wheel having 3 or 4 teeth broken off consecutively should be discarded as quite unfit for service, and replaced by a new one. If any of the pivots shows signs of wear, is rusty, or in any way rough or uneven, it must be carefully burnished till quite smooth and straight, and the ends properly rounded up. When all these points are attended to, put the centre wheel in its place in the frame, pin on the top plate with the examining pins, and see if the centre wheel runs flat with the pillar plate, or, in other words, that the pinion is upright. If it is not upright, rest the edge of the pillar plate on the workboard, and hold a small filing block upon the edge of the top plate in such a position that a few smart taps with the hammer will put the frame in its proper position. This being done, the depths, end-shakes, and pivot holes claim attention. First, try the great-wheel depth with the centre pinion, observing particularly at the same time that the fusee stands quite upright in the frame, for if it leans at all towards the barrel, most likely the chain will not run on properly, but slip up the fusee. See that the pivot holes are of the right size, and the end-shakes correct; if not, alter as may be necessary. Try, in the same manner, the centre-wheel depth with the third pinion, the third-wheel depth with the fourth pinion, and the fourth-wheel depth with the escape pinion, taking care to remember the pivot holes and end-shakes. Observe, also, that the centre wheel is free of its bed and the third wheel of the pillar plate.

In verge watches, it is very essential that the mainspring should be adjusted to the fusee, for the vertical escapement is so sensitive to variations of the motive force, that the time indicated would vary with the force that reached the escapement. In other escapements there is a kind of compensation in the action of the escapement which renders adjustment unnecessary. To adjust the mainspring, the barrel, fusee, and centre wheel are placed within the frame, and the top plate is pinned on. The chain is then attached to the fusee by the small hook, and to the barrel by the large hook, and wound up tight round the latter by turning the barrel arbor with a bench key. The ratchet is placed on the barrel arbor, and the spring is "set up" about half a turn—that is, the arbor is turned round about half a turn more than is required to pull the chain tight. The "adjusting-rod" (which is merely a weighted lever with sliding weight) is then secured to the winding square, and about one turn is given to the fusee. The weight is then moved along the rod, until it exactly counterbalances the force of the spring. The fusee is then turned till filled with the chain, and tested to see if the mainspring exerts the same power at the last turn as it did at the first. If the last turn will pull over the weight quicker than the first, the spring is not set up enough. If, however, it shows less power at the last turn than at the first, then it is set up too much. When the correct adjustment is found, a slight mark is made upon the end of the top pivot of the barrel arbor, and a corresponding one on the name plate or top plate, as the case may be. Another item requiring attention is to see that the cannon pinion does not confine the shake of the centre wheel, and also that the cannon-pinion teeth are free of the third-wheel teeth.

Having completed the examination of the watch, with the exception of the escapement—which for the present is assumed to be correct—it only remains to clean the different parts and put them together again. The greatest care must be taken to thoroughly clean each piece, and keep it clean until the movement is replaced in the case. Several methods are followed for giving the work a good

appearance. Some workmen dip the various parts into pure benzine, others into spirits of wine or some other liquid, which renders the removal of grease and dirt easy; but equally good results will be obtained from the following plan:—Use a good soft watch-brush, occasionally rubbing it gently upon a piece of prepared chalk or burnt bone, holding the wheels, plates, and other parts in a piece of clean tissue paper, to prevent the perspiration from the skin soiling them. As each piece is cleaned, it must be placed under a "covering glass" (a wineglass broken at the stem being generally used for the purpose), to keep it free from dust until the movement is put together again. The chain does not require brushing, but simply wiping with a clean piece of chamois leather or tissue paper. The "balance spring" (usually known as the hair spring) is best cleaned by laying it flat on the board paper and gently patting it with the brush; when very dirty or oily, the quickest way is to place it in some spirits of wine for a few minutes, and then pat with the brush.

The parts being ready for putting together, the first item to attend to is the oiling of the pivots which cannot be reached with the oiler after the movement is together. In the verge movement, these are the foot hole of the potence, the dovetail hole, follower hole, the pivots of the barrel arbor on which the barrel turns, and the jewel holes in the frame which have end-stones or cover-pieces in the lever.

The plan of putting together is as follows:—Take the potence, and, having oiled the foot and dovetail holes, screw it in its place upon the top plate, put in the escape wheel (called the "balance wheel" in the verge escapement *only*), push in the follower and oil its hole. Care must be taken to apply only a very minute quantity of oil—too much oil is as bad as none at all. See that the end-shake of the balance-wheel pinion is only just sufficient to ensure freedom, and that the wheel turns freely. Next take the pillar plate and arrange the wheels in their proper places in the following order: third wheel, centre wheel, fusee, barrel, and lastly the contrate, or fourth wheel. Put the top plate in position, and carefully guide the pivots into their respective holes, keeping the plate just tight down upon the pivots, but using no undue force. When all are in their right places, secure the top plate with the examining pins, and see that the train of wheels runs freely. In putting together, every piece must be held either in tissue paper or the tweezers, and no "finger marks" must appear on the plates or elsewhere. If the wheels all turn freely, the examining pins may be withdrawn one at a time, and replaced with nicely-fitting burnished pins of suitable length.

Adjust the name plate, as well as the slide containing the index, or regulator, and secure them with the screws. Try all the end-shakes, and see that each piece has the necessary amount of freedom without excess. Attach the chain by the small round-ended hook to the fusee, and by the large pointed hook to the barrel, and wind it regularly round the latter till the chain is pulled tight. Then set up the spring in accordance with the adjustment previously made. The pivot holes of the frame may now be sparingly oiled, also the hole in the cock which receives the top pivot of the verge. Proceed to put the verge in, exercising great care, for owing to its very fragile construction it is easily broken. Always see that the bottom pivot of the verge is fairly in the foot hole before attempting to put the cock on in place.

The arbor that carries the balance, whether it is called a verge, a cylinder, or a staff, has to be placed in a certain arbitrary position relative to the next piece which moves it, in order to ensure the correct action of the escapement. When it occupies this position, it is said to be "in beat"; when otherwise, "out of beat." This position is necessarily determined by the connection of the balance spring with the plate, and one of the functions of the balance spring is to continually restore the balance, and

with it the arbor, to its neutral position. The operation of finding the exact place for the balance spring to be secured in the stud by means of a pin is called "setting the watch in beat"; a practical method of setting the verge watch in beat is as follows:—Put the end of the hair spring through the stud, so as to bring the verge approximately to its correct position, and pin it moderately tight, taking the precaution to have the spring within the curb pins and quite flat. Put on the cock, and turn in the screw. Hold the movement in the left hand, and with the thumb of the right hand slowly and carefully press forward the contrate wheel, allowing each escape of a tooth to be quite distinct; observe how much the balance is drawn to the right in order to allow the escape to take place, and how much to the left. If it is found that the distances are equal, the watch is in beat; if unequal, the cock must be removed, the pin withdrawn a little, and the balance spring moved in the direction necessary to make the "draw" equal.

This being correct, the pin must be pressed in tight, the balance spring set quite flat, working equally between the curb pins, and finally the cock screwed firmly on. The chain can now be wound upon the fusee, guiding it carefully into the grooves by means of a pointed peg—the stopwork having been tested at the time of adjusting the mainspring. Put on the cannon pinion, minute wheel, and hour wheel, and pin on the dial. The movement will now be finished and ready for the case.

Geneva Watch.—The following remarks refer in the main to foreign watches with a Lepine movement.

Rotate the wheels connecting the hour and minute hands by the aid of a key; a glance will suffice to show whether the several depths, which should be light, are satisfactory. The wheels should not rub against one another, the plate, barrel, or stopwork. The barrel should have been previously examined to ascertain that it was not inclined to one side, as, if it were, an error would probably be made in estimating the degree of freedom. The set-hands arbor (the square of which should be a trifle smaller than that of the barrel arbor) must turn rather stiffly in the centre pinion, and the cannon pinion must be held on the arbor sufficiently tight to avoid all chance of its rising and becoming loose; for this would alter the play of the hands and motion work. Any fault found in the adjustment should be corrected at once, to avoid doing so after the movement has been cleaned. Slightly round the lower end of the cannon pinion and the steel shield, taking care to avoid forming a burr on the pinion leaves. These two pieces ought to rest on the ends of the centre-pinion pivots, and at the same time be some distance removed from the plate and bar respectively.

There must be sufficient clearance between the plate and barrel; the barrel and centre wheel; the several wheels in succession, both between themselves, their cocks, and sinks; between the balance on the one hand and its cock, the centre wheel, fourth-wheel cock, the balance-spring coils and stud on the other. The fourth wheel is frequently found to pass too near to the jewel forming the lower pivot-hole of the escape wheel. End-shake of the wheels may be tested by taking hold of an arm of each with tweezers and lifting it. This may also be done in the case of the escape wheel, but, when the cock is slight, it will be sufficient to press gently upon it with a pegwood stick, then releasing it, and observing the apparent increase in the length of pivot. At the same time, ascertain that the width and height of the passage in the cock are enough to allow the teeth, when carrying oil, to pass with the requisite freedom. Holding the watch on a level with the eye, lightly raise the balance with a pegwood point several times, each time allowing it to fall. The variation observed in the space between the collet and cock will indicate the end-shake of the balance staff.

Side play of the balance pivots in their holes can be easily estimated by touch, or by the eye, attentively watch-

ing the upper pivot through the endstone with a powerful glass, while the watch lies flat, and the lower pivot in the same manner with the watch inverted. If the endstones are not clear enough, which is rare, first remove one endstone and examine the pivot; then replace it and remove the other. It should be possible to rotate the balance until the banking pin comes against its stop, without causing the escape wheel to recoil at all, or allowing a tooth to catch outside the cylinder behind the small lip. The banking pin sometimes passes too near to the fourth-wheel staff. The U-arms should rest as nearly as possible in the middle of the banking slot of the cylinder; that is to say, they should be as far from the upper as from the under edge of this slot, so that the end-shakes may have free play in all positions of the watch. See that the balance spring is flat; that it coils and uncoils regularly without constraint; that it does not touch the centre wheel, the stud, or the inner curb-pin (with its second coil).

The rapid examination of the escapement may now be regarded as complete, if the watch in hand is merely being cleaned after having previously gone well. But if a watch that has not gone well previously, or if a new one, the action of the escapement must be thoroughly tested.

The train being in motion through the force of the mainspring or the pressure of a finger against the barrel teeth, examine with a glass all the depths that are visible. That of the escapement, for example, can be easily seen through the jewelled pivot-hole when this is flat, the watch being laid horizontal and a powerful glass used. When the action cannot be seen in this manner with sufficient distinctness, hold the watch up against the light and look through it. Depths that cannot be clearly seen, or about which any doubt exists, must be subsequently verified by touch. With a new watch, it may be found necessary to form inclined notches at the edge of the cocks or near the centre hole of the plate, so as to see the action of the depths. But it is important that the settings of the jewels are not disturbed, and indeed that enough metal is left round these holes to admit of their being re-bushed if necessary.

Invisible and doubtful depths must be tested by touch, and the requisite corrections applied after having re-polished the pivots, &c., as may be necessary. Holes a trifle large are less inconvenient than those which afford too little play, providing the depths are in good condition.

Remove the endstone from the chariot, and see that the pivot projects enough beyond the pivot hole when the plate is inverted. Remove the cock and detach it from the balance. Take off the balance spring with its collet from this latter, and place it on the cock inverted, so as to see whether the collet is central when the outer coil is midway between the curb pins. Remove the cock endstone and endstone cap, place the top balance pivot in its hole, and see that it projects a little beyond the pivot hole. Put the balance into the "figure 8" calliper to test its truth, and, at the same time, to see that it is sufficiently in poise; remember, however, that the balance is sometimes put out of poise intentionally.

Let the train run down: if it does so nosily or by jerks, it may be assumed that some of the depths are bad, in consequence of the teeth being badly formed, the holes too large, &c. To test the latter point, cause the wheels to revolve alternately in opposite directions by applying the finger to the barrel or centre-wheel teeth, at the same time noting the movement of each pivot in turn in its hole; a little practice, comparing several watches together, will soon enable the workman to judge whether the play is correct. The running down of the train will also indicate whether any pivots are bent.

Remove the barrel bar with its several attachments; also the third wheel, and, if necessary, test the unrighting of the centre wheel by passing a round broach or taper arbor through it, and setting the plate in rotation about this axis,

holding a card near the edge while doing so. This will indicate at once whether the axis of the wheel is at right angles to the plate. If a marked deviation is detected, or the holes are found to be too large, they must be re-bushed and uprighted. If the error is but slight, the axes may be set vertical by bending the steady-pins a little, in doing which proceed as follows:—Set the bar in its place alone, the screws a little unscrewed; rest the side of the bar opposite to that towards which it is to be bent against a piece of brass held in the vice, and strike the farther edge of the plate one or two sharp blows with a small woo len mallet. Experience alone can teach the workman to proportion the blow so as to obtain a given amount of deviation, and must enable him to ascertain whether it is desirable or not to pass a broach through the steady-pin holes before operating as above explained.

The centre pivots must project beyond the holes in the plate and bar. A circular recess is turned round the outer end of each of these holes so as to form reservoirs for oil. Owing to the neglect of these simple precautions, many watches, especially those that are thin, come back for repair with their centre pivots in a bad state, because the oil could not be applied in sufficient quantity, and has been drawn away by the cannon pinion or the steel shield. If the watch has a seconds hand, ascertain by means of the calliper that its wheel is upright. Finally, examine each jewel to see that it is neither cracked nor rough at the edges of the hole.

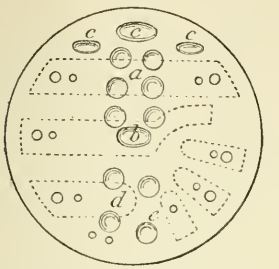
The side spring, which must not be too strong, should reach with certainty to the bottom of the spaces between the teeth of the ratchet, and this latter should be held steadily in position by the cap. The barrel is made straight and true on its axis, the arbor having been previously put in order if required. It is a good plan after making the extensive repairs here spoken of to again test the barrel and centre-pinion depth, either by touch or by drilling a hole for observation. The screw of the star wheel must not project within the cover nor rub against the dial; it must be reduced if either case presents itself.

The action of the stopwork must be well assured, especially when the actual stop occurs. It is a good plan to, as it were, "round-up" the star wheel and finger-piece, with an emery stick, supporting them on arbors. There must be no possibility of friction between the finger and the bottom of its sink. To test the stopwork, take up the winding square of an arbor, with the barrel, &c., in position, in a pair of sliding tongs or a Birch's key; hold the tongs between the last 3 fingers and the palm of the left hand, the first finger and thumb being applied to the circumference of the barrel so as to rotate it, first in one direction and then in the other. During this movement, take a pegwood point in the right hand, and try to turn the star wheel *against* the direction in which it would be impelled by the finger. The tooth that is just going to engage with the finger will thus be caused to take up the worst possible position for being turned, and thus, if the action proves to be satisfactory for each tooth, you may rest content as to the future; providing, of course, that the engagement takes place square, and there is no tendency to cause distortion of the metal. By holding the sliding tongs in a vice, both hands can be kept at liberty

It facilitates the work to secure order in taking to pieces and cleaning, preventing the screws from being mixed, &c. It is a good practice to prepare beforehand one or more boards, in which grooves and holes are made in positions to correspond with those of the several pieces on the plate of the watch, as indicated by Fig. 227. The round holes receive the cock and bar screws, which may be cleaned while the other parts are in the benzine solution. (Two holes are shown side by side for each bar and cock, so that the same plate will serve for a large and small watch.) The oval or circular hollows at *a* and round *b* receive the cap screws, and *b* the shield; *c* holds the screws of the side spring and

star wheel, and the finger-piece pin; *d* is for the screws of the top endstone, and *e* for those of the bottom endstone, &c.

FIG. 227.



Very conveniently divided deal boxes, for holding the several parts of a watch when taken to pieces, are in general use by watchmakers. They are of foreign manufacture, and measure about 6 in. by 4, and 1 in. in depth, thus being large enough to contain all the parts of any ordinary watch. Every young workman will find the advantage of noting on a paper, bearing the number of the watch, the successive operations that have to be done, striking them out one by one as the work progresses.

Whatever the system of cleaning adopted, it is essential that it be concluded by passing a pegwood point into each of the holes. Brilliancy is given to the surfaces of cleaned pieces by passing a carefully kept fine brush over them. A brush that is greasy can only be cleaned by soap and water, and a new brush is prepared for use by passing an inclined cutting edge over the ends of its bristles so as to taper them off to fine points, and to remove knots due to hard parts or to bristles becoming united. This preliminary treatment is completed by charging the brush with French chalk, and rubbing it vigorously on a dry crust of bread until the brush can be passed over a gilded surface without scratching it. The bristles are maintained in good condition by the same treatment. Billiard chalk is very effective for this purpose. The greater number of cavities there are in a crust the better it will act. Groat bread seems to be preferable to that made from wheat, because the latter contains greasy particles which prevent the brush from being kept thoroughly clean. A burnt bone is an excellent substitute for the crust, and has the advantage of causing the brush to impart a very brilliant appearance to objects on which it is used.

Cleaning with a brush is less used now than formerly, as it can be adopted with safety with the old-fashioned gilding, but is too severe for the thin galvanic coats that are applied at the present day. It may, however, be resorted to for getting up the surface of polished brass wheels, for example. Put some French chalk or powdered hartshorn (which can be bought at a chemist's) in pure alcohol. Shake the mixture, and with a fine paint-brush coat the object with a small quantity of it, subsequently brushing the surface with a brush that is in very good condition. Polished wheels may be made to present a very brilliant appearance by this means, but their teeth and the leaves of pinions must be afterwards carefully cleaned. The French chalk and hartshorn are more effective according as they have remained a longer time in the alcohol; doubtless owing to the fact that the hard grains are then more completely dissolved.

In soaping, it is advisable to use a soap that quickly produces a good lather. The object is held in the hand and cleaned by rubbing with a soft brush charged with this lather; then immerse first in clean water, and subsequently in alcohol, moving it about in each: it may be left for a few seconds in this latter, and, on being removed, is dried with a fine linen rag or soft muslin. A stroke with a soft brush in good condition will give brilliancy to the surface. If cold water dissolves the soap very slowly, employ warm. If about to soap polished wheels, the surface must be first got up with a buffstick and rouge, or by brushing with hartshorn. The balance spring may be cleaned by laying it on a linen rag doubled, and tapping it gently with a

brush charged with lather; then dipping in water and alcohol in succession. The alcohol may be used hot or cold, its action being more rapid and effective in the former case. But there is no occasion to use hot alcohol except when dealing with substances such as wax, that resist its action.

The employment of essences in cleaning watches is becoming more general every day. They are to be obtained at all the tool-shops, together with full instructions in regard to their use. A few observations may be not out of place. The objects are left in the solution for a few minutes, in order to allow all adhering matter to dissolve, but not too long, as certain qualities of benzine, &c., are apt to leave stains. Dry the pieces on removing them, and finish by passing over a fine brush that has been charged with chalk and subsequently rubbed on a hard crust or burnt bone. The following composition has been strongly recommended:—90 parts by weight of refined petroleum, and 25 of sulphuric ether. The objects are immersed for several minutes, and on removal from the bath are found to be clean and bright. It must not be forgotten that many of these essences are liable to ignite near a lamp.

The following 3 rules must be observed in arranging a system of putting the watch together: (1) avoid taking up the same piece 2 or more times; (2) hold it lightly, as any pressure will produce a mark; (3) keep it as short a time as possible in the fingers. Any linen rags used must be free from fluff, but rags of all kinds should as far as possible be replaced by certain kinds of tissue paper. The best kind will be that which, while securing a given degree of pliability, will prevent heat and moisture from passing through. Blue tissue paper should be avoided, as it is often found to encourage the formation of rust on steel-work.

The following order is often adopted in putting together the ordinary form of Geneva watch. Commence by putting the several parts of the barrel together, attaching it to the bar and observing the directions given farther on with regard to the distribution of oil. Owing to the position of the stop-finger, it is sometimes found that the mainspring must be set up either $\frac{1}{4}$ or $\frac{3}{4}$ of a turn. Very often $\frac{1}{4}$ is not sufficient, and in such cases it is necessary, before putting together, to ascertain that the spring admits of at least 5 or $5\frac{1}{4}$ turns in the barrel. If it will not allow this amount, and yet has to be set up $\frac{3}{4}$ of a turn, too great a strain will come upon the eye of the spring in winding. Fix the chariot with its endstone on the under side of the plate. Replace the fourth wheel, making sure that it is free, has no more than the requisite end-shake, and is upright. Then the escape wheel, testing it in a similar manner. See that the teeth have sufficient freedom on both sides of the cock passage, then make the 2 wheels run together with a pair of tweezers or pegwood in all positions of the plate to make sure of everything being free.

Having attached the index and endstone to the balance cock, and the balance spring to the balance (observing that the centre of the stud is against the dot on the balance rim), place some oil in both the balance pivot-holes; adjust the balance to the cock, after placing a drop of oil in the cylinder, and set in position on the plate. Some workmen apply a drop of oil to the top of the escape-wheel pivot-hole before setting the balance cock in its place, but others prefer only to add the oil after the escapement has been tested. Placing a small piece of paper first between the balance and cock, and then between the balance and plate, ascertain whether the escape wheel occupies its correct position in reference to the cylinder, in order that the escapement may act properly. This test is especially necessary in dealing with very thin watches or those in which the cylinder banking slot is exceptionally narrow.

Next fix the barrel bar to the plate. Set the third wheel in its place, and lastly the centre wheel, after putting a little oil on the shoulder of its bottom pivot. Before putting the bar over it,

apply oil to the top pivot in a similar manner; then screw it down. After this is done, screw on the third-wheel cock. Apply a small quantity of oil to the 2 centre pivots, and very lightly to the others that have not already been oiled; give a turn to the key, and listen to the tick of the watch in all positions. This should always be done before replacing it in the case. After passing the slightly-oiled set-hands arbor through the centre pinion, and adapting the cannon pinion to its end, reverse the watch, passing the end of the centre arbor through a hole in the riveting stake, so that the watch is supported on the end of the cannon pinion; a light blow of the hammer on the square end of this arbor will then suffice to drive the cannon pinion home. Some do this before replacing the movement in its case, and some after. Add a little oil to such pivots as have not already received enough, and fix in their places the remaining parts of the motion work, the dial and hands: the watch then only requires to be timed.

The distribution and application of the oil are of more importance than might be thought, and have a very marked influence on both the time of going and the rate. Very fluid oil may be used for the escapement and fine pivots, where only a small quantity is needed and the pressure is slight; but it is not suitable in other places, on account of its tendency to spread, and leave the rubbing surfaces. If too much oil is applied, the effect is the same as if there had been too little; it runs away, and only a minute quantity is left where it is wanted.

To apply oil to the coils of the spring is not enough; some must also be placed on the bottom of the barrel. Before putting on the cover, moisten the shoulder of the arbor-nut that comes in contact with it with oil: by doing so, when oil is applied to the pivot, after the cover is in its place, this oil will be retained at the centre of the boss in the cover. Moreover, it will not then be drawn away by the finger-piece, passing from this to the star wheel. The oil applied to the upper surface of the ratchet, to reduce its friction against the cap, must not be in such quantity as to spread on to the winding square. It is a good plan to round off the lower corner of this cover. The observation made in reference to the oil applied to the barrel cover may be repeated for the centre wheel.

After the drop of oil is introduced into the oil-cup of the balance pivot-hole, insert a very fine pegwood point, so as to cause the descent of the oil; a small additional quantity may then be applied. When this precaution is not taken, it frequently happens that, in inserting the balance pivot, its conical shoulder draws away some of the oil, and there is a deficiency both in the hole and on the endstone. Some workmen place a single drop of oil within the cylinder, and when the escape wheel advances each tooth takes some up. This method is unsatisfactory, because the earlier teeth receive such a quantity of oil that it runs down the pillars, where it is useless, and merely tends to increase the weight of the wheel. A much better plan is to put a very small quantity in the cylinder and on the flat of each tooth, or every second or third tooth. It will thus be evenly distributed, and will not tend to flow away. The escape-wheel pivots require but a small quantity of oil. It often happens, however, that the workman applies too much, and it runs down to the pinion. The leaves thus become greasy and stick, while the pivots are running dry.

English Watch.—Many of the remarks made in speaking of the Geneva movement are equally applicable to that of English construction. It will be well, however, to supplement them by a few special directions. The following points require attention. See that the position of dial is not altered by closing down the bezel; that the fusee dust-cap does not touch the dome or cap; and that the diamond endstone or other jewelling of the balance cock is free of the case. In $\frac{3}{4}$-plate watches the chain

is occasionally found to rub against the edge of the case, or the top plate to press against the bottom edge of the same, causing the train to bind. See that the balance and chain, and the fusee great wheel, are free of the cap where one exists: the chain is especially liable to rub after the breaking of a strong spring, which may cause the barrel to bulge, when it may also rub against the potence. Ascertain that none of the dial-plate feet or pins touch the train; that the hour wheel is clear of the third and fourth wheel bar; and the minute wheel out of contact with the dial plate, and not pressed by the dial. See that the third wheel is free in its hollow; and that the balance, more especially in oversprung watches, is clear of the barrel.

The index or regulator must be tested, especially in watches that are undersprung, at several points between "fast" and "slow," to see that it nowhere approaches too near the spring, is held with sufficient firmness, and that it never comes near enough to the guard pin for contact to occur. See that the potence screw and steady-pins do not project, and that the barrel does not touch the name plate, balance cock, top plate hollowing or great wheel. Before taking off the top plate, notice the position of the detent in the steel wheel, and the amount of its end-shake; the wear of the holes, and freedom of the train wheels; the position of the third pinion with respect to the centre wheel, and that of the escape wheel to the lever. See that the banking pins are not loose or bent; that the guard pin, which protects the balance staff when the chain breaks, is near enough to the barrel and the potence. When the watch is taken to pieces, any loose pillars or joints must be secured, pivots examined to see whether worn or bent, and those working on endstones that they come through the holes. The fourth-wheel pinion must be free in the hollow of the pillar plate and the centre wheel in its hollow; a similar examination also must be made of the collet and pin which secure the great wheel to the fusee. If a chain is broken near the barrel end, the stopwork is probably defective or the spring too strong.

The following faults may occur in English stopwork. The stop may come opposite the fusee snail too soon or too late, allowing one turn too few or too many of the fusee; or the back of the snail may butt against the stop, and thus stop the watch after going for a few hours. Overwinding sometimes occurs in consequence of the stop spring being locked between the shoulder of the stop and its brass stud; and the blade of the snail or the end of the stop may be worn or bent in cleaning. In ¾-plate fusee watches, see that the balance does not come too near to the fusee, fourth wheel, centre wheel, and sometimes the escape wheel. The breaking of a mainspring sometimes strains certain teeth of the great wheel.

In examining a lever escapement, the following particulars should always be attended to. See that ruby pin and pallet stones are firmly set; that neither pallet nor roller is loose on its staff; and that the lever and pallets are rigidly fixed together. The guard pin must be firm, the balance well riveted to its collet, the spring collet sufficiently tight, and the curb pins firm. If there is a compensation balance, ascertain that each screw is tight.

So great a variety of arrangements of the mechanism for winding watches at the pendant is met with at the present day, that it would be impossible to give detailed directions in regard to their examination; the following general remarks, however, will be found of value in directing attention to the points which most require it, and will suffice for any intelligent workman. It should be observed at the outset, that the adjustment of keyless work is almost entirely a question of depths, and the workman who has thoroughly mastered this subject will rarely experience any difficulty in dealing with keyless mechanism. Carefully observe each depth, &c., in succession, to make sure that no prejudicial friction occurs either between teeth or by contiguous

parts coming in contact. All springs should act solely in the direction in which pressure is required of them.

Special attention should be given to the intermediate steel wheel for communicating motion to the cannon pinion, when this exists, as it is permanently in gear with the train, so that any unevenness of the depth will affect the rate: if the minute wheel have too much end-shake or play on its stud, it is apt to ride on the intermediate steel wheel. The friction of the cannon pinion on the set-hands arbor must not be excessive, since it would involve too great a strain on the teeth of the minute wheel; nor too slight, since the hands would be liable to be displaced on releasing the set-hands stud. If the intermediate wheel has too much end-shake, limit this by an excentric screw overlapping its edge. Test the spring of the set-hands stud, to see that it is not too strong or too weak, and that it moves parallel with the plate. Failure in this latter particular might lead to its rising on to the rocking bar or other piece on which it acts.

Examine the winding-pinion depth, to see that it is neither too deep nor shallow. The set-hands stud spring must be strong enough to resist any accidental pressure on the stud; but, on the other hand, the strength must not be excessive, as the spring will then be all the more liable to break, besides causing inconvenience when setting the hands. The course of the spring should be banked at the point which gives a good depth between the winding and intermediate wheels. The minute-wheel stud must be firm in the plate, as any accidental binding might otherwise unscrew it, occasioning the breakage of the dial. When the minute hand is carried by the set-hands arbor, and not by the cannon pinion, care is necessary in fitting this latter, for if too loose it will rotate in setting the hands without carrying the minute hand round, and the minute and hour hand will cease to agree.

Attention must be paid to the application of oil to keyless work, as, in its absence, rust rapidly forms, and the mechanism becomes bound. Of course, all bearing surfaces, such as the interior of the pendant, intermediate and minute wheel studs, studs or screws of the rocking bar or other surfaces on which wheels rotate, must be lubricated; an equally important point is to liberally oil the teeth of the winding pinion and the bevel or crown wheel that engages with it. The application of a little oil inside and outside the cannon pinion must not be omitted.

Several watchmakers have noticed that the oil is preserved intact longer after washing with soap, if well done, than after cleaning with benzines, &c., though in some instances it may be that the latter process was not properly performed. However, the following is the method adopted for some years by Bertrand:—Dissolve in about 1 qt. of rain-water a piece of Marseilles soap, about 1½ in. square, pared very fine, and add a piece of black soap the size of a hazel-nut. Boil, filter through a linen rag, and bottle the liquid. When required for use, pour a little into a capsule, and place the parts (excepting those fixed with lac) in it, boil it slightly, and after having put back the liquid in the bottle, pass the parts through rain-water, slightly boiling, and then plunge them in alcohol. On taking them out, dry them with a linen rag. By this means the pieces are much better cleaned than they would be if benzines were used. Should the polished wheels turn a little brown, the colour may easily be made to disappear by passing lightly over the stained portion, and without touching the steel, a pencil-brush dipped in water mixed with potash oxalate (commonly called salts of sorrel), and dipping in water and alcohol. If necessary, it may be touched up with a dry chamois leather.

Pivoting.—This may, in some respects, be called the most tedious of any work connected with watch repairing; for it is certainly no easy job for the novice to drill down the *centre* of a small pinion, especially when the pinion is left extra hard, which is often the

case. Making the drill to the required shape and hardness is one of the main things to be considered. A needle is the best steel to be obtained for this job. Heat the needle in the flame of a candle to a cherry-red, then hammer it into shape. This must be such a form as will give as much strength as possible; therefore, do not hammer the sides too flat, or the edges will snap off when hard. It must not be too pointed for drilling steel, but will work very well without a point, provided a nice cutting shape is obtained, which is secured by making the end a little larger than the other part, and slightly flattened with the round-faced hammer, then stoning up so that there is an edge in the centre of the flattened part. If this edge is slightly rounded instead of pointed like a brass drill, it will make the drill cut longer than the pointed shape, as there is more of the cutting surface utilised at one time; therefore there is not the amount of wear on any particular point of action, so it will cut long after a pointed drill has become dulled. To get the drill extra hard, hold it in the candle flame until it becomes a cherry-red, then immerse in quicksilver. Do not get it to a white heat, or the steel will be too brittle, and never cut satisfactorily. A candle is much better than gas for making up drills, as the gas burns the steel, owing to the sharp current of air through the burner. Some use water and some oil to harden the drills, while others use the tallow of the candle. Either will have the desired effect, providing the steel has not been heated too much before putting in—a deep red is quite sufficient.

Suppose the drill is hard enough to cut down the required steel where the pivot is wanted—say a verge third-wheel bottom pivot. After finding the centre, apply plenty of oil to the drill, then drill down until you get about the depth of a pivot's length. Now file the steel a perfect fit to this hole. There is no better steel for the pivot than a needle, brought down to a plum colour. When it is stoned to fit the hole tightly, drive it in with the flat hammer. If it is a good fit, you may now cut it off a little longer than required, run a point on it, put the point into the turns, and see if the pinion runs true. If so, the pivot may soon be finished; but provided you have got the pivot a little out of the centre, you must make the point a little out of the centre of it, so that the pinion will run true; then turn it true before you begin with the pivoting file, or you will find the pivot will never find the centre by filing. Great care should be taken in getting the point of the pivot in the proper place before beginning to turn. With care, pivots may be put in so that the watch will not suffer therefrom. Even if it is a wheel, whose being out of poise does not matter, it will throw the depths unequal, providing the pivot is out of the centre. It is sometimes rather tedious to get the pinion true from the point of pivot as advised, but there had better be a few minutes taken there than to slip the job and then have a bad depth to correct.

In putting in a verge fourth pivot, if it be a seconds pivot, drill the pinion far enough, or, as before, the length of the seconds pivot—this will make a firm job of it. Care must be taken not to break the drill in; but with a properly shaped drill and a steady hand there is not often a break.

Whether verge, lever, or Geneva pivots, they can all be done in the way stated, but of course a Geneva escape-wheel pivot requires more practice than a third-wheel pivot of a verge watch. With this the wheel must be taken off in order to get the ferule on to run it with. In putting on the wheel again the best tool to use is a pinion riveting tool, as it is then left nice and flat. No watchmaker should be without this tool, as it is so useful for all kinds of riveting where accuracy is required. It will leave the brass perfectly polished where it is used to rivet a balance on.

There are pivots where the drill is not used. Some drill in the turns, others use the mandril, with the wheel shellacked firmly in it, holding the drill on

the rest; while others employ the old-fashioned method of holding the wheel in the hand and running the drill in the vice holes. The operator may choose his own method.

Now for a pivot without any drilling—a staff top pivot for instance. Drive out the old staff entirely (the steel part of it), then cut off the steel about half as much as reaches through the brass; stone the end flat, then put it in again as before. This will leave a hole in the top part. Put a piece of properly tempered steel in this hole, solder it in with a small portion of solder, then centre the point so that the body of the staff runs perfectly true; put it in the turns, and turn down to required shape for pivot, finishing off with file and burnisher. This is the best method for a staff top pivot, which can be done without much fatigue. Of course this method cannot be resorted to when it is a solid steel staff, such as the Waltham staffs. In this case the drill has to be used; but when the operator has had plenty of practice with the turns he would be very likely to put in a new staff rather than a pivot. Even in putting in a new staff (English), the steel can be driven out, and another piece put in, saving the trouble of turning the brass. In doing this, care must be taken to get the old brass to run true on the centres before using the graver, or the balance will be out of poise.

We now come to the easiest pivot job, although by some it is thought to be a very delicate and tedious job—the cylinder pivot. Provided the top plug is a good fit, but has the pivot broken, simply drive out the plug a little way (the length of the pivot) and run a new pivot on the same plug; turn it back a little way to give it a good appearance. This may be done complete in 10 minutes; so it is not very serious after a little practice has been had at it. In driving out the plugs, make a steel stake with holes through and chamfered on the top; this will let the plug move while the shell is held firmly on the stake.

New Mainspring.—The barrel cover being removed by the blade of a small watch screwdriver, the arbor is first taken out and then the broken spring. If, without doubt, the broken spring was the original spring, and the watch is of fair quality, it is well to follow the rule generally adopted by the trade, and replace it with another of "the same width and strength." Frequently, however, it happens that the spring is not the original, but one put in by some careless workman either ignorant of what conditions a spring should fulfil, or contented with the nearest spring to the original that he happened to possess. In such a case, the general rule does not apply.

Suppose, by way of example, that you have a broken spring to replace, which evidently is not of the proper width and strength for the barrel it occupied, and consequently not adapted to the watch. The first consideration is its width, which should be as great as the barrel will fairly admit, reaching from the bottom of the barrel to the groove barely, excepting where the barrel cover is hollowed out, when it may reach it fully. If the spring is not wide enough, its working will be irregular; if too wide, then it will bind in the barrel. The next point is the thickness, and it is most important that this should be correct for the watch to perform satisfactorily. If the spring is too thick, the action of the escapement will be hurried and its rate unsteady, and the chain more liable to break; while, if too thin, the escapement will be sluggish, and the watch apt to stop altogether. The strength of the spring should be such that, when of the proper length, hooked in the barrel and wound up, it may cause the barrel to make about $\frac{3}{4}$ of a turn more than is required by the length of a chain that occupies the fusee when fully wound. The length of a spring should be such that when wound in the barrel it should occupy about $\frac{1}{3}$ of its diameter. Having gauged the width and found the corresponding springs, one of the proper strength will be found as a rule to be a little larger in diameter than the barrel, or one that

would almost fill the barrel if it were wound in, so that it is necessary to break off a short piece that the barrel may not be too full. This applies to the springs as bought from the makers, coiled within a wire ring, and is merely given as an approximate guide to selection.

Having selected a spring apparently suitable, it must be shortened as much as is necessary, and "hooked in," when it must be finally tested by holding the barrel tight in the left hand and winding up the spring by means of a pair of sliding tongs attached to the squared end of the barrel arbor, and observing how many times it causes the barrel to revolve. If it makes an insufficient number of turns, the spring is too thick; if too many, it is too thin. Although this may be stated as a general rule, it is not without exceptions, as, for example, in verge watches it is occasionally expedient to use a somewhat weaker spring than will only make the proper number of turns, owing to an imperfect and unequal balance wheel not admitting of a close and correct escapement. There are 2 methods of hooking in mainsprings: in one the hook is in the barrel, and the spring only requires a hole in it near the end; in the other the hook is attached to the spring, a hole being formed in the barrel to receive it. In replacing a spring which only requires a hole in the end, it must be carefully tempered by means of a very small flame, so applied that the spring may be gradually and equally tempered from the end where the hole is to be, which should be rather soft, to about ½ in. of its length. The hole should be square, as being the least liable to constrain the spring, and prevent its proper action in the barrel. It is usual, after making the hole, which is punched with a pair of mainspring nippers, to pass a file lightly across the end of the spring and round off the corners, giving it a neat and workmanlike appearance. When the hook is to be attached to the spring, the latter is tempered in the manner already described, and a small round hole is punched in it. A piece of "hooking-in" wire is then fitted to the hole in the barrel, and placed in the jaws of a pair of sliding tongs in such a manner that a pivot may be filed on it to fit the hole in the spring, and cause the piece of hooking-in wire to form a hook standing at the proper angle to suit the hole in the barrel. The hooking-in wire is then put in the vice, and the mainspring is firmly secured to it by riveting, when the length of the wire is cut off, leaving only sufficient to form the hook. The end of the spring is usually finished like the other, but left pointed instead of round.

New Barrel-hook.—When this is necessary, it is always a good plan to put in one of steel, and not brass, as they frequently are. The hook should be "tapped" in very tight and nicely shaped, not standing up too high in the barrel.

Tightening Barrel-cover. — When a barrel cover is loose, it should be covered over with a piece of thin paper and gently tapped with a round-faced hammer all round the edge, which, if carefully done, will spread the cover a little without marking it.

New Barrel-arbor.—There are 3 kinds of arbor commonly in use—the plain English, the plain Geneva, and the Geneva with solid ratchet. The fitting of a new one of either kind requires to be done very carefully, it being absolutely necessary that the pivots should be accurately fitted, and the end-shakes very exact, for the barrel to run true and give satisfaction. Either of the plain arbors can be made from a piece of ordinary round steel, or an "arbor in the rough" may be obtained from the tool shops. In the former case, it will be necessary to turn the steel somewhat to shape in the lathe; but when bought in the rough, the arbor is quite ready for the more exact turning which is done in "the turns." A screw ferule is attached to one end of the arbor, and the body or centre part is first turned to the proper width and diameter, the measurement being taken from the old arbor by means of the pinion gauge. The arbor is then turned down and

polished until it fits the holes in the barrel just tight, when a round broach passed lightly into the holes will give the necessary freedom.

If an English arbor, the next step will be to turn the top pivot and fit it into the name plate, and afterwards file the square on the other end of the arbor to receive the ratchet. If, however, it is a Geneva arbor, the square for the stop-work finger-piece must be made, and the lower pivot finished first, and the top or winding square (which also receives the ratchet) last. In filing these squares, great care must be taken to make them really squares. The best plan to ensure success is to turn a line where the square is to end, and file them up in the turns between the centres. The ends of the squares and pivots are usually finished in the screw-head tool. The hook to take the mainspring is formed by drilling an oblique hole in the body, and driving in very tight a piece of good tempered steel, which is then filed to shape. In case of a Geneva arbor with solid ratchet, it is necessary to buy the arbor in the rough, and advisable to have that kind which is half finished, for the body is then screwed on and the ratchet polished. It is almost impossible to tap a good thread with the ordinary screw-plates suitable for this purpose; and if an arbor not already screwed by the proper plates must be used, it will be found much better to accurately fit on the body with a plain round hole, and secure it with a good steel pin. This latter kind of arbor is generally found where the barrel is "hanging" on the bottom pivot of the arbor, unsupported.

New Barrel.—When it becomes necessary to put in a new barrel, as it sometimes does, either from the barrel cracking, across where the "hooking" is, or from unskilful treatment having spoilt it, the best plan is to send the arbor and old barrel to the material dealers, and have a new one of the same diameter fitted to the arbor. The new barrel will require very little finishing, and it is much better and cheaper than attempting to make one.

Repairing the Chain.—A very frequent occurrence is the breaking of the chain, and to repair it neatly and strongly only a small amount of application is required. One end of the broken chain must consist of a double, and the other end of a single link. It is easy enough, by means of a sharp penknife, to get the single link, but the double one is sometimes more difficult to obtain. The best plan is to rest that end of the chain at which the double link is required upon the filing block, and, with the thumb-nail of the left hand, keep one end of the pair forming the double link tight together, while with the penknife you gently separate the other, so as to loosen the rivet first from one side and then the other. If the chain is then held in the left hand and the small piece of broken link is firmly grasped with the pliers and a sharp pull given, it will be found that the double link is made and ready to receive the single one. When the ends to be joined are placed in position, they should be secured by a rivet made of chain wire; but in the absence of this, a needle, properly tempered to a blue colour, may be used, taking care not to leave the rivet too long. Also remember that the hooks are placed the right way to hook in the barrel and fusee. When a new chain hook only is required, it will be found much easier to turn the chain than the hook, when the latter happens to lie the wrong way.

Chain running flat or off the Fusee.—When a chain runs flat, when working back on to the barrel, or slips up the fusee when winding, it must be carefully examined, and the cause found out. Sometimes it results from the chain being too large; then the only remedy is a new chain. At other times it will be found that the delicate spiral projections on the fusee which separate each turn of the chain from the next have become bruised and perhaps broken in places, so that the safe retention of the chain cannot be relied on. If the damage is very serious, the fusee should be re-cut, but if only trifling, it may be rectified by carefully raising the

injured part to its proper position and then placing it in the turns, and allowing a graver of suitable shape held in the right hand to lightly scrape out the grooves as the fusee is slowly turned with the left. When the chain runs off without any apparent cause it may be frequently altered by changing it end for end, or by taking a very little off from the outer lower edge of the chain along its entire length. When all these means fail, by putting in a new hole for the top fusee pivot, so that the fusee inclines away from the barrel, a certain cure will be effected, as this must evidently cause the chain to run in its proper position.

Fitting Hairsprings is frequently a source of much trouble for the novice. First get to know what train the watch has; this, of course, will necessitate your knowing the number of teeth in the fourth wheel and escape pinion; that is, if it is a seconds watch; if not, you will have to know the whole train from centre wheel. Now if we find the watch has to beat 18,000 per hour, we get the hairspring that will be the proper strength to make the balance oscillate 300 per minute, or 5 per second. This is done by fastening the centre of the spring to one of the pivots with a piece of beeswax; but notice that the centre of the spring has been made the *proper size* for the collet before being tried, as a spring with its old centre—as made—will be so that it gives its beats slower than when the centre has been broken out to make it fit; therefore when this is correct, and waxed to one pivot, we take hold of the outer coils of the spring, just where the spring is the proper circumference for this coil to reach the same place as the stud and the curb pins. This will be the proper size, but to get the proper strength, we notice the beats it will make, by placing the other pivot on a watch-glass, holding the tweezers about where it should be pinned in the stud; by giving the balance a slight move we soon see the number of beats it will make in a minute, by counting and watching the seconds hand of the regulating clock. If it is a train which requires 16,200, we then have to get the spring of such a strength that it will make 270 vibrations per minute; but it is best to count every alternate vibration, making the counting 135 per minute for the 16,200 train. If it goes a little over or under this number move the tweezers a little along the spring till you find the exact place where the number is correct; this is just the place to pin in the stud, and the watch will be to time. With the 16,200 train the watch beats 4½ times per second; but some of the old-fashioned levers and Genevas beat only 4 per second; this, of course, can be counted by taking every *alternate beat* until you get 120 per minute. Those who follow this method will be able to set the spring and return it at once ready timed.

Weakening the Hairspring.—This is effected by grinding the spring down. Remove the spring from the collet, and place it upon a piece of pivot wood cut to fit the centre coil. A piece of soft steel wire, flattened so as to pass freely between the coils, and armed with a little pulverised oil-stone and oil, will serve as your grinder, and with it you may soon reduce the strength of the spring. Your operations will, of course, be confined to the centre coil, for no other part of the spring will rest sufficiently against the wood to enable you to grind it, but this will generally suffice. The effect will be more rapid than one would suppose, therefore you will watch carefully, or you may get the spring too weak before you suspect it. Another and perhaps later process is as follows:—Fit the collet, without removing the spring, upon a stick of pivot wood, and having prepared a little diluted nitric acid in a watch-glass, plunge the centre coils into it, keeping the other parts of the spring from contact by holding it in the shape of an inverted hoop skirt with your tweezers. Expose it a few seconds, governing the time of course by the degree of effect desired, and then rinse off, first with clean water, and afterwards with alcohol. Dry in the sun or with tissue paper.

To clean a Hairspring, immerse it in benzine and leave it there for a few minutes; if you watch it, you will see all the little particles of dirt and oily matter leaving the spring; after they are all off, lay the spring flat on the paper and just hold the chamois leather in your finger and press carefully on the spring: this will soon dry it.

Cleaning a Dial.—First dissolve ½ oz. potassium cyanide in hot water: to this add 2 oz. strongest ammonia and ½ oz. spirits of wine. Dip the dial for a few seconds, and immediately immerse in warm water, brushing it lightly with soap; this will soon show a clean dial; then rinse, and dry off in hot boxwood dust. Some use diluted nitric acid for cleaning dials, or soda hyposulphite will do it, if dissolved and mixed with ammonia; but with either of these the painted numbers go with the dirt, so only dials with gold numbers can be done with this process.

Fitting Dials on Geneva Watches.—Amongst the various repairings it will often happen that new dials are required to replace damaged ones, and it is well known how seldom the feet of these new dials correspond with the old holes in the plate. The making of new holes sometimes meets with some obstacles, as they (the holes) occasionally would come in contact with parts of the movement. In such cases, it is best to cut the feet off, and carefully file flat with the enamel, then hold the dial in the proper place on the plate, and mark through the old holes the place for the feet to fill these holes; remove the enamel on these marked places with an emery file until a small space of the copper is laid bare. Then cut 2 feet out of an old dial, so as to leave a small plate on them, and solder these to the places for the purpose on the new dial. With a little care and practice the experiment will not fail to give the desired result, as regards strength of the feet and the neat fitting into the proper holes.

Timing a Watch.—To effect the best possible results in timing an ordinary watch to the various positions, it is absolutely necessary to strictly observe the condition of the pivots of the cylinder or staff in lever, &c., escapements, and the jewel holes in which the pivots run. The pivots ought in all cases not to be unnecessarily long, be made conical at the shoulder and elongating, perfectly cylindrical for about 1½ the length of the jewel hole, in order to rest freely on the cap jewel. When the watch is in a horizontal position, the point of the pivot should be quite flat, with merely the sharp edge removed and well polished; a pivot so constructed will work easy in all positions, and be least exposed to bending or breaking. The hole in the jewel should always be of the same length as the width of it, which is the proper size to equalise the friction of the pivot, whether the watch be in vertical, horizontal, or slanting position. If the hole is found to be larger than the diameter, the length can easily be reduced with the aid of a diamond drill, the end of which to be of a round instead of a sharp-pointed shape; or too large a hole may be reduced in a few seconds. The bars of the polished steel effected in the hollow of the jewel is quite immaterial to the action of the pivot, as long as it is kept clean. Last of all, the balance should be carefully poised, and the balance spring be kept quite flat and free.

PHOTOGRAPHY.—A long article on this subject appeared in the 1st Series of 'Workshop Receipts,' but since that time many new processes have come into use, and will be discussed here.

Gelatine Processes. *The Gelatine.*—Dry-plate makers are aware that the quality of gelatine varies as regards tendency to frill, and their idea that this tendency is governed by the amount of water different specimens will take up is generally but not altogether true. Different gelatines dry in different times, and throw those stains upon the plate which are the cause of the tendency to frill. Abney prepared a solution of gelatine of such a strength that 5 gr. of the colloid were made to form a film upon each quarter-plate; after being dried, the films were stripped from the

glass and accurately measured. Some were then placed in water to soak; others were treated with ammonia of the strength usually employed in developing, while more were soaked respectively in solutions of monocarbonates of soda and potash, in which they were allowed to swell for one hour. The results showed that ammonia promotes swelling, whilst the monocarbonates of potash and soda have less tendency so to do; consequently they are in this respect better for developing.

An easy method of getting emulsion to flow freely over a glass plate is to cover a squeegee with swans-down, and to rub it over the plate just before coating with emulsion. Abney's experiences with silicates as a substratum to promote the flow of gelatine have not been good. Warnerke is in favour of the use of monocarbonate of potash, as it gives less tendency to frilling. Gelatine is firmer the quicker it is developed. When you want to avoid frilling, add alum (up to 5 per cent.) to the first washing water in which the emulsion is squeezed out in fine threads; the succeeding washings clear out the alum again. Use ordinary alum—not chrome alum. The threads become crisp under the treatment, and do not increase in bulk. The plates develop quicker than when there has been no treatment with alum at all, but the increase in rapidity of development is small.

Sebastian Davis states that, if gelatine be moist for a long time, decomposition has a tendency to set in near the centre of the plate. He made one batch of plates with Heinrich's very hard gelatine, and another batch with Nelson's No. 1—a very soft gelatine. The latter were 4 or 5 days in drying without artificial appliances for the purpose, whilst the former dried in 48 hours under similar circumstances. The hard gelatine has no direct tendency to blister.

Spiller states that alum, or a very little zinc sulphate (about ½ per cent.) is sometimes put into glue by the manufacturers to promote the hardening. The effect of metallic salts upon gelatine ought to be tried by experiment, for probably some of them will be found to give the plate much less tendency to frill.

Capt. Abney states that his experience with soft gelatine artificially hardened is that its expansive power is materially lessened. If plates were 48 hours in drying he should be astonished if they did not frill and blister. He should get perfect fog under the circumstances. The use of a substratum prevents the mark round the edge of the plate in drying. Not less than 8 hours or more than 24 hours is the best time for drying, and quick drying by alcohol tends to blistering. Altogether, 16 hours is a good time for the drying of plates. England's experience in relation to the effect of slow drying on the centre of the plate shows that his emulsion was not sensitive enough at the time of coating if he desired the maximum of rapidity. Zinc nitrate has a hardening effect upon gelatine, and with the use of zinc bromide for decomposing the silver nitrate, there is no risk of getting slowness; but the zinc salt is not so "certain" as the potassium salt.

Emulsions.—(1) Burton and other well-known photographers advise the "acid boiling" process for making the emulsion, the operation being conducted in a very slight deep-ruby light. The formulæ used by Burton are:—

(*a*)	Silver nitrate	400 gr.
	Water	8 oz.
(*b*)	Ammonium bromide ..	220 gr.
	Ammonium iodide	15 gr.
	Ammonium chloride ..	15 gr.
	Gelatine (Nelson's No. 1)	80 gr.
	Water	8 oz.
	Hydrobromic acid, enough to make the solution just acid.	
(*c*)	Autotype gelatine	450 gr.

soaked in water, and afterwards squeezed to get rid of as much of the water as possible.

Iodide is recommended by Capt. Abney, and adds greatly to the quality

of the plates. Although ammonium chloride is used in the preparation of this emulsion, it is not intended that there shall be any silver chloride in the emulsion. The bromide and iodide are just estimated to convert the silver, using Wernerke's practical equivalents. The reason for using the chloride at all is that a greater degree of sensitiveness is gained by boiling in presence of an excess of chloride than with an excess of bromide. Probably no advantage arises from the presence of silver chloride in the emulsion.

The amount of gelatine used in emulsification is rather greater than is sometimes recommended, the quality of the plate being thereby improved. The reason why no definite quantity of acid is given, is because the chemicals themselves are frequently acid. Success in getting a very sensitive, and at the same time clear emulsion, greatly depends on the amount of acidity of the solution. It should be just acid enough to show by litmus paper. If this is the case when the salts are first dissolved, nothing more is wanted. If not, add very dilute hydrobromic acid, till the solution will just turn blue litmus paper red. If it has been neutral at first, about one drop of strong hydrobromic acid will suffice.

Autotype gelatine is the best for the bulk, as frilling never occurs with it. It is very hard setting, but at the same time does not repel the developer as some gelatines do. Somewhat more than the quantity given may be used, if it be desired.

To emulsify, pour the solution (*b*) into a glass bottle; afterwards add, little by little, the silver nitrate, both solutions having been raised to a temperature somewhere approaching the boiling-point. The whole is then poured into a large beaker or jelly-can; this is covered with a wooden dish and placed in a saucepan. The lid of the latter is put on, and the whole is allowed to boil. Coat a plate with the emulsion newly made: on looking at a light through the plate, the light appears ruby red. The emulsion is said to be "red by transmitted light." As the process goes on, however, the colour changes, and at last it becomes blue. It is difficult to say exactly when the whole of the silver bromide has been converted into the blue variety, but it may be discovered by gently drying a plate coated with the emulsion. The blue bromide and the red bromide will separate into patches. When all is converted to the blue, the boiling may cease. The time taken in boiling seems to vary considerably with different manipulators: generally somewhere between 1 and 2 hours; but it may be continued for several hours without producing fog, so long as the emulsion is kept distinctly but slightly acid. The bulk of the gelatine is then added, and the whole is poured out in a flat dish to set.

When set quite stiff, it is cut up and placed in the "squeezer." It is pushed through wire gauze into a hair sieve held under water. This cuts it into very small particles, and if water be allowed to run through the sieve for ½ hour, the soluble salts will all be washed away. After this, the sieve is allowed to stand a short time, for some of the water to drain off. The emulsion is then heated, filtered through 2 folds of a pocket handkerchief, and spread on the glass. Use a small teapot as a pourer. Pour the emulsion on the plate while the latter is on the levelling shelf. Then take a glass rod in the finger and thumb of each hand; dip this rod into the pool of emulsion on the plate—the emulsion runs by capillary attraction along the rod to the edges of the plate, but no farther. Lift the glass rod about a $\frac{1}{10}$ in.; the emulsion rises with it. Pass it rapidly first to one end of the plate then to the other, guiding yourself by keeping your thumb and finger on the levelling shelf, and the plate is absolutely evenly coated. It is never removed from the levelling shelf till it is set. The plates are slightly warmed to begin with. When set, they are reared on ends in racks; then placed in the drying box to dry.

Plates prepared as described are quite as rapid as the average of the so-called

instantaneous plates sold commercially. Capt. Abney first pointed out that an emulsion got more rapid by keeping it cold after it was washed. This only happens when the emulsion is alkaline, or at least not acid. If to the emulsion, made as described above, about 8 drops of strong ammonia be added to the pint, it will be found that, after a week's keeping, the plates made from it will be 2–3 times quicker than before, and quicker than any commercial plates. This adding of a few drops of ammonia, simply to neutralise any acidity which may be in the emulsion, must be by no means confused with the process where digestion is carried on in the presence of 1–2 per cent. of ammonia, before washing.

It is not worth while for an amateur to make his own plates, if he expects to economise by it. It is easy to make a moderately rapid emulsion, and to make a number in succession with uniformity, but it is not so easy to make the plates. It is on their coating and drying that the difficulty comes. Then, if an exceedingly rapid emulsion is required, the difficulties become very great; the amount of light admissible is so small, that manipulation must be performed more by feeling than by seeing.

An important question is the temperature of the coating and drying room. As regards coating, with the gelatine he used, Burton prefers to have the room about 60°–65° F.; if colder than that, he warms it; 65° F. is the highest that ought ever to be used for drying, unless the natural heat of the air is greater. By lowering the air below the natural temperature, you produce a certain amount of dampness. The temperature should never be raised above 65° F. If you have a very dry room, you may keep it below that. As regards the method of applying heat, use a very small room, heated with a gas-stove, the products of the combustion of which must be carried outside; if working in a large room, arrange to draw air down the outside of the flue from the draught-box between it and a sliding cylinder fitted outside of it. (*Soc. Arts J.*)

(2) Lockett (N. Stafford. Photog. Assoc.) gives the following directions:—

In the first place, all utensils are made as clean as possible. A large saucepan is filled with water, 20 gr. of gelatine put into a bottle with 6 or 7 oz. of water, and 112 gr. AmBr, 6 gr. KI, and 4 gr. AmCl; 2 drops hydrochloric acid; heat the water in the saucepan, place in it the bottle until the gelatine is dissolved, coat, and add by red light 200 gr. $AgNO_3$ in crystals; shake until dissolved, which may be known by the sound. Put this in a dark place until convenient for boiling; will keep in this state for 3 weeks without experiencing any ill effect.

The boiling is done by placing the bottle uncorked in a covered saucepan containing water, which is brought to boiling-point if kept there for 60 min., shaking occasionally; when cold, the full quantity of gelatine is added, viz. 20 gr. per ounce, stirring well up from the bottom, and pouring into a dish to set. When cold, squeegee the emulsion (after being scraped up from the bottom of the dish with a card) through muslin into a solution of potash bichromate, stir it up with a strip of glass, and leave for ½ hour or more; then place in a sieve and drain well, afterwards well wash in running water for an hour, drain, melt again, and make up to 10 oz. The addition of alcohol is unnecessary, unless you wish to keep the emulsion, when cover it with methylated spirit.

The plates are cleaned, and a substratum of sodic silicate-solution in water ½ per cent. is applied with a sponge, and allowed spontaneously to dry. This is an effectual cure for frilling, and at the same time it renders the operation of coating more easy, allowing the emulsion to flow like collodion without the use of spirit. The emulsion is warmed and passed through 4 thicknesses of flannel into a jug; again pour upon the plates as with collodion, but only slightly drain and then place upon cold glass plates to set, which they do in 10 minutes. Afterwards place upon racks in a well-ventilated drying cupboard,

the door of which is not opened until they are judged to be quite dry, or marks will occur in them. These plates give thin images unless plenty of bromide be used. The best proportion is:—4 gr. ammonia, 3 gr. ammonia bromide, 2 gr. pyrogallic acid (commonly termed simply "pyro") per oz. of water. But if any one gives the common soda carbonate a trial, he will prefer it to ammonia. Use a saturated solution, with which and 1 gr. pyro and 3 ammonia bromide, you will get denser and brighter negatives than with 2 gr. pyro and ammonia.

(3) Although somewhat slower than a bromide emulsion, the chloride possesses greater scope for positive printing than can be attained with the bromide. A. L. Henderson adopts the following formula for a chloride emulsion, which is very practical and useful:—

Hard gelatine	80 gr.
Water	1½ oz.
Silver nitrate	75 gr.
Water	½ dr.

The gelatine and silver are dissolved separately, then mixed, the silver solution being warmed and gently poured into the gelatine. To this is next added (stirring the silver solution all the time):

Dry sodium chloride ..	21 gr.
Potassium citrate ..	21 gr.
Dissolved in water ..	½ dr.

which is warmed. The emulsion is poured into a dish and allowed to set. The jelly is now cut into strips, and washed in the usual way; cold water should be used, as the emulsion is very thin. The wash should be carried on under a yellow light. After washing, the emulsion is melted by heat and to it are added:

Salicylic acid	3 gr.
Dissolved in alcohol ..	2 dr.
Chrome alum	1 gr.

Dissolved in a small quantity of warm water. After the emulsion is filtered, the plates are coated with it in the usual way. The film is extremely thin, on account of the watery composition of the emulsion. If more contrast is wanted, the emulsion should be made thicker by the addition of gelatine. As it will not keep well, only small batches should be made at a time, enough to cover the plates to be coated.

Opal plates coated with the emulsion are printed behind a negative in a frame in the same manner as with ordinary silver paper; the picture will appear on the surface in the same way. The exposure varies with the density of the negative, and may readily be ascertained by exposing a piece of paper coated with the same emulsion behind the negative. After printing, the plate is first well washed, and is next toned with the ordinary gold chloride and borax toning bath; it is again well washed, and fixed for 10–15 minutes in a hypo bath of 21 per cent. strength; is washed well and soaked again for a few minutes in an alum bath, washed, and dried.

(4) A. L. Henderson has recently made some improvements on what is termed his cold precipitation process of making gelatine emulsions. The formula is as follows:—

(*a*) Distilled water	1 oz.
Nelson's No. 1 gelatine	5 gr.
Potassium bromide ..	180 gr.
Potassium iodide ..	2 gr.

The above is heated just enough to melt the gelatine; next is added—

Alcohol	4 oz.
(*b*) Distilled water ..	1 oz.
Alcohol	4 oz.
Silver nitrate	240 gr.

Both the above solutions may be prepared by day or gas light.

(*c*) In the dark room, by a non-actinic light, such as a faint ruby light, ¾ oz. ammonia, 880°, is added to 2½ oz. of (*b*), which converts half of the silver solution into ammoniated silver. This is next mixed with the remaining 2½ oz. of (*b*), and the whole is poured into (*a*) and well stirred. Silver bromide is thus formed, and it only remains to

raise the temperature and add gelatine to complete the operation.

The emulsion, in a beaker, is next set into a water bath, the temperature of which is 120° F. (49° C.), and 240 gr. of dry, hard gelatine (Heinrich's) is added, the liquid being continually stirred until all the gelatine has melted. It is then set away to cool, and in a short time the silver and gelatine coagulate at the bottom of the beaker into the form of a cake. The alcohol, about 8 oz., is next poured off and preserved for future use.

The emulsion cake is then broken up into small pieces, and subjected to a 2–3 hours' washing in constantly changing water; it is then remelted by means of the hot-water bath as before stated, and enough distilled water is added to increase the bulk up to 11½–14½ oz.; then—

Thymol	6 gr.
Dissolved in alcohol	4 dr.

is added, and the emulsion is complete; after being filtered it can be flowed upon plates. If it is desired to mix up a small batch, ½ or ¼ of the pellicle cake may be remelted, and the proper proportion of water and thymol added. The pellicle cake will retain its sensitive qualities for any length of time if kept in the dark.

Some of the advantages of the process are that successive batches of emulsions of uniform sensitiveness can be made with great certainty; emulsions can be economically made; less alcohol is required; the gelatine extracts all the water from the alcohol, leaving it free (or nearly so) from the nitrates, which will be found crystallised at the top of pellicle cake; lastly, the alcohol can be continually used over and over again as a vehicle to promote emulsification, provided it is carefully filtered each time and added to the silver and bromide in the dark room, allowance being made for the ammonia it contains.

(5) The process preferred by *The British Journal of Photography*, is based on W. K. Burton's principle, though varied in the details. Following is the formula:—

(*a*)	Gelatine	30–50 gr.
	Potassium bromide	300 gr.
	Water	20 oz.
(*b*)	Silver nitrate	1 oz.
	Nitric acid	1 m.
	Water	1½ oz.
(*c*)	Potassium iodide ..	15 gr.
	Water	1 dr.

The 3 solutions having been made, commence their mixture by cautiously adding, drop by drop, the solution (*c*) to the solution (*b*), agitating after each addition. The first effect will, of course, be the formation of a precipitate of silver iodide, but this is rapidly redissolved by the excess of silver nitrate until the solution becomes saturated. Under favourable conditions, the full quantity of iodide may be thus added—that is to say, if the silver solution be sufficiently concentrated and its temperature not too high. However, the addition of iodide is continued until a permanent milkiness remains, when the remainder of the iodide, if there be any, is set aside until again required.

The solution (*a*) is now raised to boiling-point in the ordinary digester, and (*b*) is added to it in the usual manner, and thoroughly mixed by shaking or stirring. When this is done, the remainder of (*c*) is added, and the cooking is proceeded with by any of the methods in vogue, e. g. the ordinary boiling process, which is carried on to the verge of the blue stage if an emulsion of moderate rapidity only is required, or further in proportion. Or, after allowing the emulsion to cool, ammonia may be added, and the whole digested at a low temperature for an hour or so.

By the above plan of adding the iodide, a very fine state of division is ensured, as well as a higher degree of sensitiveness. The proportions of silver and haloids are so near the point of neutrality that very little trouble will be experienced in securing a rapid deposition of the sensitive precipitate; but if it should exhibit a reluctance to subside, longer digestion with ammonia or

longer boiling, as the case may be, will bring about an improvement. An emulsion made in the evening will have invariably subsided sufficiently by morning to allow of the first change of washing water being made; 3 such changes in all will prove ample.

The precipitated bromide, having been thoroughly washed, is transferred to a suitable flask or bottle; or, preferably, the washing may be performed in one of the conical precipitating or "parting" flasks, obtainable at any chemical glass warehouse. Into this is introduced 200 gr. hard gelatine, such as Heinrich's, previously swelled in distilled water, and sufficient water to make the bulk up to 10–12 oz. Heat is applied, and, as the gelatine dissolves, the flask is vigorously shaken to secure the thorough emulsification of the bromide. If, as will probably be the case, the bromide show a tendency to retain a slight granularity, it will be necessary to raise the temperature to about 200° F. (93° C.), or even higher, and to keep it there, with occasional agitation, until the necessary degree of fineness is attained. It is for this reason —the probable necessity for the application of a high temperature—that the albumen is not added until the last stage of the operation.

While the above operations are proceeding, take the whites of the necessary number of eggs, and beat them into a stiff froth without the help of water, ammonia, acetic acid, or any of the ordinary additions. For the above quantities of the ingredients, 4 oz. liquid albumen will suffice, or, roughly, the whites of 4 eggs. These having been converted into froth of such consistency that the vessel containing it may be reversed without any loss of albumen, the latter is transferred to a clean funnel of sufficient size, placed in a bottle or other vessel to catch the albumen as it gradually reliquefies, which it will do in the course of a few hours.

The emulsion, when it has gained the requisite degree of fineness, is allowed to cool down to 90°–100° F. (32°–38° C.), when the albumen is poured into it, and thoroughly mixed. All that now remains is to make the bulk up to 20–24 oz. (according to taste), to filter, and the emulsion is ready for coating.

Emulsion made in this manner sets rather more slowly than usual, owing to the smaller proportion of gelatine it contains, but dries rapidly to a hard, glassy film. The films appear thinner and more transparent, especially when dry, than ordinary ones, but show no deficiency in the matter of density. Should still greater hardness be required, if the plates are to be long kept or subjected to the vicissitudes of travel, they may be passed singly, after drying, through a dish of good methylated alcohol carefully filtered. This will coagulate the albumen, and though it gives a little extra trouble the return is worth the outlay.

Such plates are moderately sensitive, giving, with $\frac{1}{2}$–$\frac{3}{4}$ hour's boiling, 15 on the sensitometer. They develop quickly, owing, no doubt, to the comparatively porous character given to the film under the action of the alkaline developer. The ammonia, indeed, seems to penetrate instantly, by its solvent action on the albumen, to the very glass itself.

Other methods of precipitation, such as Abney's, may be adopted if preferred, or Monckhoven's silver carbonate and hydrobromic acid process may be employed, provided the albumen is not added until the silver bromide has been fully formed. But the plan described in detail seems to be the simplest.

The hardness of such films appears to offer a fair prospect of their possessing good keeping qualities, and if no impediment in the way of reduced sensitiveness should intervene, albumen films will probably be much employed in the future.

(6) The glass plates are well cleaned, and flowed with a preliminary coating of 1 part syrupy solution of potash or soda silicate, 5 of egg-white, and 60 of water. Beat to a froth, and filter. The excess is drained off the plate, which is then placed in a nearly upright posi-

tion till dry. The emulsion consists of:—

(*a*)	Silver nitrate ..	100 gr.
	Distilled water ..	2 oz.
(*b*)	Potassium bromide	85 gr.
	Nelson's No. 2 gelatine	20 gr.
	Distilled water ..	1½ oz.
	Water containing 1 per cent. hydrochloric acid	50 m.
(*c*)	Potassium iodide ..	8 gr.
	Distilled water ..	½ oz.
(*d*)	Hard gelatine ..	120 gr.
	Water	several oz.

When the gelatine is thoroughly soaked, let all possible water be poured off (*d*). (*a*) and (*b*) are now heated to about 120° F. (49° C.), after which (*b*) is gradually added to (*a*) with constant agitation; then (*c*) is added. Heat in a water bath, and stir in (*d*). After washing, add ¾ oz. alcohol. To emulsify, pour the solution (*b*) into a glass bottle; afterwards add, little by little, the silver nitrate solution (*a*), both solutions having been raised to a temperature somewhere approaching 120° F. (49° C.), and (*c*) is next added.

(7) Knebel offers the following formula: (*a*) 20 parts hard gelatine (Winterthur) are soaked in 200 of distilled water (1 in 10 by weight) and afterward dissolved by heating. He then adds 24 parts potassium bromide and ¼ part potassium iodide in solution, and 3 or 4 drops acetic acid or 0·1 part citric acid. (*b*) He dissolves 30 parts crystallised silver nitrate in 100 of water. (*c*) A gelatine solution for subsequent use is made of 14 parts hard gelatine and 6 of soft gelatine, for summer use; but if it is to be used in winter, 10 parts of each are taken. They are softened first, and then dissolved in 250 parts water. The solution (*b*) is *gradually* poured into the solution (*a*) and the vessel is rinsed with half as much water (50 parts), which is also added. The emulsion is now digested for 2 hours on a water bath at 150°–160° F. (65°–70° C.). It is quickly cooled to 86° F. (30° C.) by placing it in cold water. Next, 6 or 7 parts ammonia (sp. gr. 0·920) are added to (*c*), which must be nearly cold and not very fluid. It is well stirred and then poured into the emulsion, which is at 86° F. (30° C.), shaken thoroughly, and filtered through flannel and afterward in Braun's apparatus, after having first been pressed through canvas and well washed. It is now ready to be poured upon the plates to dry.

(8) Another method, by Pizzighelli and Hubl, called the cold method, is as follows:—

(*a*) 1 part gelatine, 50 of water, 2 of ammonium carbonate, 15 of ammonium bromide, 2 of potassium iodide solution (1 to 10), 140 (by volume) of 92 per cent. alcohol, and 1–5 of ammonia water.

(*b*) Silver nitrate, 20 parts in 100 of water.

(*c*) Hard gelatine, 24–30.

The constituents of (*a*) are mixed in the order thus given, except the gelatine, which is softened and dissolved, then added. The more ammonia, the softer and more sensitive the photographic film. The emulsion is formed as usual by adding (*b*) to (*a*), under the well-known precautions. They are digested as usual about 5 hours, then the emulsion is poured into a beaker glass and (*c*) is stirred in, allowed ½ hour to soften, and completely dissolved on a water bath. It is now rapidly stirred, and 500 parts (by volume) of strong alcohol is added, which precipitates the emulsion. The lumps that form are melted in small portions and poured into cold alcohol, stirred with a glass tube 2 in. in diameter, closed at the lower end. The emulsion attaches itself to the tube, and is then washed ½ hour in flowing water.

(9)	Silver nitrate	1 oz.
	Water	10 „
	Gelatine, hard	1 „
	Sodium chloride ..	½ „
	Water	10 „

Let the gelatine soak for a short time, and then dissolve by placing the vessel in water at about 110° F. (43° C.), and warm the silver to the same tempera-

ture. Now take into the dark room, and mix by any of the well-known methods, so as to form a very fine emulsion. It may now be cooled by placing the containing vessel in running water; when cold, wash, remelt, filter, and coat in the usual way. (A. Cowan.)

Developers.—(1) For the development of gelatino-bromide plates, Egli & Spiller recommend the following solutions:—

(*a*)	Hydroxylamine hydrochloride	32 gr.
	Citric acid	15 gr.
	Potassium bromide ..	20 gr.
	Water	1 oz.
(*b*)	Caustic soda	1 dr.
	Water	1 oz.
(*c*)	Potassium bromide ..	20 gr.
	Water	1 oz.

For a 7½ by 5 plate, the film is first soaked for about 1 minute in 3½ oz. water containing 1 dr. of (*a*), about 20 drops of (*b*) are then added, and, if necessary, an extra 10 or so. Should the image show signs of over-exposure, or if the plate is one of the specially sensitive kind, a few drops of (*c*) must be used to restrain the action still more. The advantages resulting from the use of this developer are that the image is of a *wet-plate* tone, perfectly free from stain or deposits; a great variation of exposure is permissible; and the solution is not acted on by the atmosphere, and therefore does not deteriorate during development from external causes.

(2) By J. Edwards:—

(*a*)	Neutral potash oxalate	2 oz.
	Ammonium chloride	40 gr.
	Citric acid	2 dr.
	Distilled water	20 oz.
(*b*)	Iron sulphate	4 dr.
	Alum	90 gr.
	Distilled water	20 oz.

Add 1 part of (*b*) to an equal part of (*a*), but do not reverse this by adding (*a*) to (*b*), or the result will not be so good. If the plate is properly exposed, the result will be a fine purple-black tone in the transparency. If you like a warm brown tone, expose double the time, and add an equal bulk of water to the developer. The development in this case will be much slower. To fix the picture, use 1 part of hypo to 8 of water. After fixing and washing, put the plates for ½ minute in the following:—

Alum	1 oz.
Sulphuric acid	1 oz.
Water	20 oz.

This will dissolve the opalescence caused by the oxalate. The plate must now be well washed, dried, and varnished in the usual way.

(3) H. J. Newton gives the following formula for a developer well adapted to bring out fully the details in a plate which has had a very short exposure:—

(*a*)	Water	1 oz.
	Soda carbonate	15 gr.
	Potash yellow prussiate	15 gr.
	Soda sulphite	5 gr.
(*b*)	Water	1 oz.
	Ammonia chloride ..	7 gr.
	Pyro (dry)	6 gr.

(*a*) and (*b*) are mixed, and the whole is poured over the plate. Development commences within a minute, and is usually finished at the end of 3–4 minutes. The proportions named above are correct for an ordinary drop-shutter exposure, but they are not arbitrary; they may be varied to suit different cases, as, for example, should the plate have been greatly under-exposed, equal parts of (*a*) and (*b*) (with the pyro left out of the latter) may be added, a little at a time, to 3–4 times the strength stated, until all the details in the shadows are brought out, without danger of producing green fog, which frequently appears from the excessive amount of ammonia sometimes used in the ordinary ammonia and pyro developer. In case of over-exposure, ½ gr. to the ounce of developer of sodium bromide is added, and the solution is diluted with water.

The (*a*) and (*b*) solutions may be kept in a more concentrated form, and diluted

for use. The following are the right proportions for 10 per cent. solutions:—

(*a*)	Water	9½ oz.
	Soda carbonate ..	480 gr.
	Potash yellow prussiate	480 gr.
	Soda sulphite	160 gr.
(*b*)	Water	9 oz.
	Ammonia chloride ..	510 gr.
	Solution of 1 drop sulphuric acid in 1 oz. water	1 drop
	Pyro (1 oz.)	437 gr.

If (*b*) does not change from purple to a clear yellow colour within an hour after mixing, 1 or 2 drops more of the sulphuric acid solution may be added.

To prepare a developer of the proper strength with the above solutions for the development of a 5 × 8 plate which has had a drop-shutter exposure, take:

Water	5⅓ dr.
(*a*) solution	2⅔ „
Also:	
Water	7 „
(*b*) solution	1 „

Mix the two, and develop in the usual way. The proportions given will be equivalent in grains to those stated in the first formula.

Newton has described some interesting experiments, which substantiate very forcibly the value of the developer for instantaneous work. Two plates exposed precisely the same time, on the same object, were developed side by side, one with the developer as prescribed in the directions of the manufacturer of the plate, and the other with the above developer. With the ferrocyanide, there was ⅓–½ more detail brought out in the shadows, and development was completed sooner than with the prescribed developer; the negatives being more brilliant and vigorous. For photo-micrography, the process is admirable. The exposure appears shortened by fully ¼, and negatives abounding in detail, strength, and density are easily obtained. The colour of the negatives is not the nice black-and-white given by potash, but is of a strong olive brown, and very non-actinic. Owing to this fact, care must be taken not to push the development too far, or unduly dense negatives will result. The ferrocyanide developer has advantages in cleanliness and freedom from green fog, as compared with ordinary pyro and ammonia, and is more powerful, requiring much less exposure of the plate. During cold winter weather it works exceedingly well, and uniformly brings out brilliant and plucky images.

One word of warning: there are some makes of plates that will not stand this developer without fogging, unless bromide be used. The same may be said of plates that have received an excessive exposure. It is best with every plate to start with 2 drops of a 10-gr. per oz. solution of potassium bromide, increasing the dose to 6–8 drops if necessary. Using the bromide, you can count on every plate turning out a success with a much shorter exposure than usual, say ⅓–½, which is a decided advantage when working with artificial light.

(4) Joshua Smith has recently explained advantages in the use of lime water over ammonia in the development of gelatine plates.

He first slakes 1½ oz. lime by covering it with water overnight, in a wide-mouthed bottle. He then pours it into a mortar and grinds the lime to a paste, which is next diluted with water and the whole decanted into a 2-gal. bottle. Any remaining sediment can be ground, diluted, and decanted in the same way. When the whole has been added, the 2-gal. bottle is filled to 2 gal. with water, the solution is shaken well and allowed to stand for an hour to settle. It is then filtered, and is ready for immediate use. The strength of the solution should now be tested, which is done by first making a solution of 3½ oz. water and ½ oz. acetic acid. Into 2 oz. of the lime water (in which is placed a piece of blue litmus paper) 1 dr. and 20 m. of the acid solution is poured. This should just turn the litmus paper red, and will be a standard test. The strength of the lime solution will remain

uniform, no matter what the temperature may be—a point of great importance. The solution will keep any length of time.

To prepare the developer, for 1 or 2 days' use, take 40 oz. of the filtered lime water and add 1 oz. of an 80-gr. solution of ammonium bromide. To develop, pour into a graduate 6 oz. of the bromo-lime water, add a small mustardspoonful of dry pyrogallic acid, shake, and pour over the plate laid ready in the developing tray. The image will soon appear and gain strength. If the plate was over-exposed, add a few drops of the bromide ammonium solution and a few grains of pyro. Very clean, clear, chocolate-coloured negatives are produced with this developer. Any tendency to fog may be overcome by the addition of a little more ammonium bromide.

(5) Where the photographer intends to travel, and develop on the route, it is very desirable to reduce his chemical outfit to the smallest bulk and to the fewest liquids possible. G. Cramer, the dry plate manufacturer, gives the following formula for a developer, which he considers gives the best of results, and at the same time has the advantage of extreme portability:—

Stock Solution.

Soda sulphite (crystals) ..	3 oz.
Ammonium bromide ..	½ oz.
Potassium bromide	1½ oz.
Pyrogallic acid	2 oz.
Dissolve in distilled water	32 oz.
Add sulphuric acid (c. p.)	120 m.
Aqua ammonia (strongest)	3 oz.
Water to make up bulk to	40 oz.

The sulphuric acid and aqua ammonia should be measured very exactly. Instead of 3 oz. of crystals, 2 oz. of granular soda sulphite may be substituted to produce the same effect. Dilute a sufficient quantity for one day's use as follows: For ordinary purposes, 1 part in 11; for very short exposures, 1 part in 3–6; for over-exposed plates, or in all cases where great intensity and contrast are desirable, 1 part in 20. This developer may be used repeatedly if it is always returned immediately to the pouring bottle, which should be provided with a tight-fitting rubber stopper. As long as the solution remains transparent, it is good; but when it looks muddy, its use should be discontinued.

(6) Henry J. Newton has lately discovered a new solution, which, when added to the ordinary soda carbonate developer, increases its developing power fivefold, thereby allowing sensitive plates in the camera to be exposed a much shorter time than is usual. He makes the following solution: 4 oz. water, in which is dissolved mercury bichloride 60 gr.; into this solution is poured a solution of 90 gr. potassium iodide; 1 oz. water. To every 2–3 oz. of the soda developer he adds 2–3 m. of the above solution. Clear negatives of good tone and quick printing quality are produced. Details in the shadows are brought out with greater facility. It is especially useful in the development of plates which have had an instantaneous exposure. He also found 2–3 m. of a solution of 150 gr. sodium iodide to 1 oz. water had a quickening effect, but not so much as the mercury solution.

(7) For preserving from discoloration, 2 oz. of sulphite is quite sufficient for 1 oz. of pyro. The formula then will run: Pyrogallic acid, 1 oz. Dissolve in water containing 30 gr. citric acid, and add solution of soda sulphite, as above, 4 oz. Then make up the whole to 10–20 oz., according to the operator's usual plan. You have then a stock solution easily made, always in order after the lapse of months, and capable of developing a negative perfectly free from the well-known yellow colour of pyro.

Various samples of the sulphite do not exhibit much difference in their respective effects; but it will be well to point out that, as this salt is not found in every chemist's shop, stress should be laid upon the fact, when ordering, that *sulphite*, not *sulphate* or *sulphide*, is wanted. Chemists are so used to their

customers' ignorance of chemical nomenclature, that they might think an error had been made in asking for a little-known chemical.

The special kinds we tried were the commercial and the recrystallised sulphite, the latter costing 4–5 times as much as the former. The latter is a nicer-looking and a purer salt; it possesses no superiority in its colour-preventing properties, but may be decidedly recommended on the grounds of its probable greater uniformity.

(8) In reference to excessive contrast, presuming the exposure to be correct, the fault lies more in the developing than in anything else. A slow development, with the cautious addition of the ammonia as required, tends to produce a far more harmonious picture than the usual way of pouring the strong ammonia solution at one operation over the plate. A method well suited for interior work is as follows:—

Pyro Solution (keeps good for about a month).

Pyrogallic acid	72 gr.
Citric acid	24 gr.
Potassium bromide	32 gr.
Water	1 oz.

Dissolve the citric acid in the water before adding the pyro.

Ammonia Solution.

Ammonia, ·880	2 dr.
Water	1 oz.

Keep in stoppered bottles.

To develop, give the plate the ordinary soaking in water, and pour over it:

Pyro solution	1 dr.
Water	3 oz.

Allow this to act on the film for at least 2 minutes. Then put ½ dr. of ammonia solution into the developing cup, pour the pyro from the dish into it, and back again to the plate in the usual way. On the appearance of the image, add another ½ dr. of ammonia solution gradually, and more if required. (H. Mansfield.)

(9) Hydroquinone or quinol will bring out a fully developed picture with at least half the exposure necessary when pyro is employed. This appears strange, when it is observed how much more powerfully pyro absorbs oxygen; but the explanation probably is in the fact that hydroquinone is more gradual in its action, and has a more "selective" power than pyro. With a collodio-bromide film, for instance, which is not so much protected from chemical action as a gelatine one, pyrogallic acts with such energy, when mixed with an alkali, that the whole film is reduced immediately, and no image, or only a faint one enveloped in fog, appears; hence there must be used a powerful restrainer to keep this action within bounds. A soluble bromide, which is usually used, has this effect; but, unfortunately, at the same time, partially undoes the work which the light has done, rendering it necessary to give longer exposure. But with hydroquinone no restrainer is necessary unless a great error in exposure has been made. It does its work rapidly and clean, in this resembling the ferrous oxalate; it does not discolour during development so much as pyro, and consequently does not stain the film so much, while full printing vigour is very easily obtained without having to resort to intensification. The colour and general appearance of the negative are more like the wet-plate process, since the shadows remain so clear and free from fog. It seems almost impossible to fog a plate with it.

A collodio-bromide, or even a collodio-chloride, plate exposed in the camera will develop clean and rapidly without any restrainer. This property of developing a chloride is surprising, and will probably be very important; 1 gr. to the oz. is strong enough for most purposes. With some samples of hard gelatine, it is advisable to use 2 gr.; but with most kinds, and with collodion, 1 gr. is quite sufficient. Banks prefers using it with a saturated solution of washing soda as an alkali: 2–3 drops of this to the oz. of solution of hydroquinone rapidly develops the

image, and the addition of a few drops more to complete development is all that is needed. A soluble bromide acts very powerfully as a retarder and restrainer. With a mere trace added, development is very much slower. Although its cost is greater than pyro, 1 oz. of it will go as far as 2 oz. of pyro, so the difference is not so much as it appears. No doubt, if a demand sprang up for it, the price would also be reduced considerably. Another useful property of this developer is its suitability for developing on paper either a bromide or a chloride film, whether it be produced by an emulsion, or by the older method of first brushing over the paper the haloid, and afterward the silver. The clearness with which it works renders it very suitable for this purpose, and for enlargement or printing enables pictures to be obtained with very short exposures.

(10) Experiments with the soda developer in all of its different forms have resulted in G. H. Monroe adopting the following formula as being the simplest and giving the finest negatives. The sal soda developer has been objectionable, both on account of the slowness of its action and the green colour given to the films. These objections have now been overcome. All possible variation in the plate can be secured, from thin clear negatives to any amount of contrast and density.

(*a*)	Soda sulphite (cryst.) ..	4 oz.
	Hot water	11 oz.

When dissolved and cool, acidify with 3–4 oz. sulphurous acid. Add 1 oz. dry pyro. Filter.

(*b*)	Sal soda	3½ oz.
	Soda sulphite	¾ oz.
	Water	64 oz.

To develop, use 1 dr. of (*a*) to each oz. of (*b*). By using more or less of (*a*), any change in density may be secured, more pyro producing greater contrast, and *vice versâ*. If, upon the first appearance of the image, a negative is found to be over-exposed, lift the plate out of the developer and pour over it from a bottle a solution of potassium or ammonium bromide (5 gr. bromide, 1 oz. water), letting it run off the plate into the tray containing the developer without draining off too much; place the plate in the tray and proceed with development. The above operation can be repeated with the same plate in extreme cases.

This developer has the valuable property of not becoming discoloured in use; it also imparts to the film the very desirable grey colour, and the whole operation of development is complete in 2–3 minutes. Sufficient may be made in the morning for the day's use, and it can be used over and over again without in any way deteriorating, provided it has not been necessary to add restraining bromide, which changes the condition of a normal developer. The developer should be returned to a wide-mouthed bottle with a rubber stopper after each use of it, and the tray rinsed out and set up to drain. Should this formula not give strong enough contrast, add 1–3 gr. of dry pyro. This will hasten and produce the desired result.

The development should be carried to about the point desired in the finished negative.

It sometimes happens that the washing of the finished negative changes the grey colour to a greenish cast, which can be instantly removed by immersing the plate in the following solution:—

Common alum	8 oz.
Citric acid	1 oz.
Water	32 oz.

Should the plates show any signs of softness in warm weather, immerse them in a strong alum solution after development and before fixing. The sal soda developer, unlike the ammonia, has a persistence of action, and in instantaneous exposures, interiors, and portraits does not give any hardness. The time of exposure is also decreased by ⅓, as there are no restraining bromides present.

(11) Dr. Eder has for a considerable time directed especial attention to the soda and potash developers, either of

which seems to offer certain advantages over the ammoniacal pyrogallol. This advantage becomes particularly apparent with emulsions prepared with ammonia, which frequently show with ammoniacal developer green or red fog, or a fog of clayish colour by reflected, and of pale purple by transmitted light. Ferrous oxalate works quite well with plates of that kind; so do soda and potash developers.

For soda developers, Eder uses a solution of 10 parts pure crystallised soda in 100 of water. For use, 100 gr. of this solution are mixed with 6 gr. of a pyrogallic solution of 1 : 10, without the addition of any bromide.

(12) More pleasant to work with is Dr. Stolze's potash developer. (*a*) Water, 200 c. c.; potassium carbonate, 90 gr.; sodium sulphite, 25 gr.; (*b*) Water, 100 c. c.; citric acid, $1\frac{1}{2}$ gr.; sodium sulphite, 25 gr.; pyrogallol, 12 gr. Solution (*b*) is for its better keeping qualities preferable to Dr. Stolze's solution.* The solutions when in well-stoppered bottles keep well for some time. To develop, mix 100 c. c. of water with 40 min. of (*a*) and 50 min. of (*b*). The picture appears quickly and more vigorously than with iron oxalate. If it is desirable to decrease the density of the negatives, double the quantity of water. The negatives have a greenish-brown to olive-green tone. A very fine greyish-black can be obtained by using a strong alum bath between developing and fixing. The same bath after fixing does not act as effectually in producing the desired tone. A bath of equal volumes of saturated solutions of alum and ferrous sulphate gives the negative a deep olive-brown colour and an extraordinary intensity, which excludes all possible necessities of an after intensification.

The sensitiveness with this developer is at least equal to that when iron developer is used, frequently even greater.

The addition of bromides is superfluous, sometimes injurious. Bromides in quantities, as added to ammoniacal pyro, would reduce the sensitiveness to $\frac{1}{10}$ or $\frac{1}{20}$; will even retard the developing power almost entirely.

Must a restrainer be resorted to, 1 to 3 min. of a 1 : 10 solution of potassium bromide is quite sufficient.

(13) H. J. Newton communicates a formula for an improved developer for gelatine plates which he has found by experiment to be particularly valuable in the development of instantaneously exposed plates, and to produce negatives of a superior colour and quick printing quality. He makes 2 stock solutions in the following proportions:—

(*a*)	Water	1 oz.
	Anhydrous soda carbonate	48 gr.
	Potash carbonate ..	48 gr.
(*b*)	Water	1 oz.
	Soda sulphite	48 gr.

To develop a 5×8 plate with a drop-shutter exposure he pours in the graduate 6 dr. each of (*a*) and (*b*), and then adds $11\frac{1}{2}$ oz. water and 6 gr. dry pyrogallic acid. It may be mixed $\frac{1}{2}$ hour before use if desired. The soda sulphite keeps the solution clear.

If the exposure has not been too long, the developer will rapidly bring out the image; the development should be carried on until the whites of the shadows have turned a steel grey colour. If the plate has been over-exposed, the developer should be diluted with water and restrained with 2–3 gr. sodium bromide to each oz. of developer, which may be in the form of a 10 per cent. solution. If the plate has been known to have been greatly over-exposed, development should be commenced with 1 dr. each of (*a*) and (*b*) to $2\frac{3}{4}$ oz. water and 3 gr. dry pyro, adding a little of each at a time should the picture develop too slowly.

(14) The following developer, containing ammonia and ammonium sulphite, has proved excellent with almost all kinds of commercial plates.

(*a*) Dissolve 10 parts pyrogallol, and 25–30 of ammonium sulphite, in 100 of water.

(*b*) Dissolve 5 parts ammonium brom-

* 100 c. c. water; 10 c. c. alcohol; 10 gr. pyrogallol; 1 gr. salicylic acid.

ide in 150 of water, and add 50 of liquid ammonia.

The working developer is made by mixing 100 gr. water, 4 gr. of the pyrogallic solution (*a*), and 4 gr. of the alkaline solution (*b*). Development takes place very quickly, and if it is desired to make the reaction slower, more water (50 gr. extra) is added. This leads to the production of softer pictures. If, on the other hand, more vigorous images are required, a few drops of a 10 per cent. solution of ammonium bromide must be added. The ammonium sulphite developer gives very well-modelled, brilliant negatives, in which the high lights are well rendered, and the deep shadows are full of modelling, while the negatives have an agreeable dark-brownish tint. The ammonium sulphite makes the aqueous solution of pyrogallol more permanent than when the sodium sulphite is used, and there is but little liability to fog with it.

(15) A Developer with Lime Water.—Pyrogallic acid and lime water were first recommended by Davanne for collodio-bromide emulsion, and this developer can also be used with gelatine emulsion plates. As lime is but slightly soluble in water, it is convenient to make a 10 per cent. solution of sugar in water, and to saturate this with slaked lime. The pyro-lime developer becomes violet and brown in use, also becomes turbid; while the developed images produced are very thin.

(16) By Col. Dawson. Pyrogallic Solution.—Remove the cork from a 1-oz. bottle of pyrogallic acid, and pour into it 30 gr. citric acid dissolved in 6 oz. water; shake up, and then add to the contents in the bottle 4 oz. powdered neutral recrystallised soda sulphite. Fill the bottle with cold water up to the bottom of the neck, shake up until the crystals are dissolved; transfer to a stoppered bottle The contents will be about 10 oz., and will keep a year at least; every 10 minims represent about 1 gr. pyro and 4 gr. sulphite. (N.B.—Ordinary commercial sulphite is useless for the purpose). This solution is to be used with the two forms of developer.

Developer A. Make up the following solutions:—

(*a*) Ammonia, ·880	1 dr.
Water	9 dr.

This is a 10 per cent. solution.

(*b*) Potash bromide	24 gr.
Water	1 oz.

This is a 5 per cent. solution.

A good commercial gelatine plate properly exposed should develop perfectly with—

Pyro	2 gr.
Sulphite	8 gr.
Ammonia, ·880	2 m.
Potash bromide	1 gr.
Water to make	1 oz.

or taking the 3 stock solutions—

Pyrogallic	20 m.
Solution (*a*)	20 m.
Solution (*b*)	20 m.
Water to make	1 oz.

Developer B. This is an excellent developer, and gives splendid tones; it is suitable for landscape work or transparencies for the lantern, but is too slow in action for professional studio work. A negative or transparency is not fully developed much under 15 minutes; patience is needed, for any attempt to hasten development will be sure to result in failure.

(*a*) Common washing soda	480 gr.
Potash carbonate ..	480 gr.
Potash bromide	20 gr.
Water to make	20 oz.

A good commercial gelatine bromide plate, properly exposed, either as a negative or a positive, should develop perfectly with—

Pyro	3 gr.
Sulphite	12 gr.
Common washing soda ..	3 gr.
Potash carbonate	3 gr.
Potash bromide	$\frac{1}{10}$th gr.
Water to make	1 oz.

Or,

Pyro solution	30 m.
Solution (*a*)	60 m.
Water to make	1 oz.

The proportions given are for 1 oz. of developer; any number of ounces of either formula can be made with the same proportions. With both developers, Col. Dawson recommends half only of the A (*a*), or half of B (*b*) being mixed with pyro and water at first, the half in reserve being added as development progresses.

With developer B certain precautions are needed. Plates thickly coated, or rich in gelatine, are apt to blister or frill. Plates prepared without being hardened by alum are apt to frill.

Forcing development is apt to produce blistering.

After ½ hour or more, the colour of the developer should not be darker than sherry.

Allow time to force an under-exposed plate; you will not find any advantage (but the contrary) in forcing with excess of B.

If a plate developed with A proves under-exposed, wash it well and apply B; this may save it.

If a plate is over-exposed when developed with A, wash it well and continue the development with

Pyro solution	.. ..	60 m.
Solution B	.. ..	30 m.
Water to make	.. ..	1 oz.

With B developer it is absolutely necessary that the plate should be well washed after development, and immersed for 2–3 minutes in

Chrome alum	.. ..	1 oz.
Hydrochloric acid	..	1 dr.
Water	.. ..	20 oz.

then be again well washed and fixed.

The colour of image is warm black, the shadows as clear as glass, with no stain or discoloration of any kind.

(17) With the pyro ammonia developer, made by the Platinotype Company, use ammonia solution, viz.:—

Ammonia	.. .. ..	1 oz.
Water	.. ..	2 oz.
Bromide	.. .. ..	70 gr.

To develop a half-plate, take 2 oz. water and add 80 drops of sulpho. pyro (every 10 drops of sulpho. pyro contain 1 gr. pyro) and 6–8 drops of ammonia solution. Flood over the plate, and watch till the picture appears. This developer is slow, and takes a minute or so to appear; when the image is well out, add 10 drops more ammonia solution, and keep on till dense enough, which is soon learnt.

(18) Usual Pyro Developer.

(*a*) Strong liquid ammonia		1¾ oz.
Potassium bromide	..	240 gr.
Water	.. .. ..	80 oz.
(*b*) Pyrogallic acid	.. ..	30 gr.
Water	.. .. ..	10 oz.

In case of an ordinary exposure, mix equal volumes.

(19) Beach's Developer.

Pyro Solution.

Warm distilled water	..	2 oz.
Soda sulphite	.. .. ..	2 „

Dissolve; and when cold, add

Sulphurous acid	.. .. ..	2 „
Pyrogallic acid	.. .. ..	½ „

Potash Solution.

(*a*) Water	.. ..	4 „
Potash carbonate	..	3 „
(*b*) Water	.. ..	3 „
Soda sulphite	.. ..	2 „

(*a*) and (*b*) are now combined into one solution, which will measure 8–9 fl. oz. To develop an 8½ × 6½ plate which has had a drop-shutter exposure, take 3 oz. water, and add thereto ½ oz. of (*a*) and 3 dr. of (*b*) of the potash solution, increasing the latter to 5 dr. in case the image hangs back. For a plate which has had the proper exposure, or which has been somewhat over-exposed, add to the 3 oz. of water 3 dr. of (*a*) and 1 dr. of (*b*). After a minute's time, if the image fails to appear, add a second dram of the potash, repeating the additions at intervals of a minute until developing commences.

(20) Oxalate Developer.

(*a*) Saturated solution of neutral potash oxalate. To 1000 parts of this add 3 of saturated solution of ammonium bromide.

(*b*) Saturated solution of iron sulphate. To 1000 parts of this add 2 parts saturated solution of tartaric acid.

For use, take 4 parts of (*a*) to 1 part of (*b*). If picture is under-exposed, add a little more of (*b*).

(21) Sulphite Developer.

A. Soda sulphite	.. ..	4 oz.
Water	.. .. ..	40 oz.

Dissolve; add sufficient of a saturated solution of citric acid to produce a slight acid reaction upon litmus paper; now add 1 oz. pyrogallic acid, and make up bulk to 54 oz. with water. This gives a solution, each oz. of which will contain about 8 gr. of pyrogallic acid.

B. Ammonia, ·880	..	1 oz.
Potash bromide	..	180 gr.
Water	.. .. ..	40 oz.

Equal parts of this will give a 4-gr. pyrogallic solution, a strength which is a good average.

(22) Warnerke's Sulphite Developer.

(*a*) Potash carbonate	..	45 gr.
Sodium sulphite	..	12 „
Water	.. .. ..	1000 „
(*b*) Pyrogallic acid	..	12 „
Sodium sulphite	..	24 „
Citric acid	.. ..	2 „
Water	.. .. ..	1000 „

For a normal development, equal proportions of (*a*) and (*b*) are used.

(23) Pyrogallic Solution.

Pyrogallic acid	.. ..	1 oz.
Citric acid	.. ..	60 gr.
Water	.. .. ..	109 oz.

Dissolve the citric acid in water, and add the pyrogallic. The solution will contain 4 gr. pyrogallic to the oz. of water, and will keep good for months. For convenience, half the quantity of water may be used, when the strength will be 8 gr. per oz. In using it, dilute according to formula employed.

Intensifiers.—(1) According to W. Brooks, the greatest drawback to gelatine plates has been the want of a proper intensifier after fixing. Many negatives are perfect in every respect except for the want of a little more density to bring them up to proper printing quality. Several methods of mercurial intensification have been put forward; but to no purpose, as the negative changes by light more or less. The objection to mercury in any form is that when you attempt to alter a negative you never know how much or how little intensity you will get after its application; again, there is always more or less clogging or blocking up of the fine detail, with the result, in 9 cases out of 10, of absolute ruin to the negative. Many thousands of negatives have been sacrificed in this way.

Photographers are more certain than formerly, in the early days of the gelatine process, in getting their negatives somewhere near the mark as to density. But at times one is apt to be a little out in judgment, and fall a little short; and for the want of a ready and reliable system of intensification many stick fast. Brooks made innumerable experiments in this direction, and felt certain that the result must be gained by redevelopment with silver after fixing, as with a wet plate.

It is a well-known fact that to develop a gelatine plate with alkaline pyro, the developer must be much more powerful than we dare use to develop a collodion emulsion plate. In his own work Brooks uses a much stronger developer than that usually recommended—generally as much as 10 minims of liquor ammonia in his developer, well restrained with ammonium bromide; and, by being able to use such a powerful developer, it occurred to him that, to gain the desired end, we must work in the same direction as regards an intensifier, and he found his surmises correct. Some years since, he tried other fixing or clearing agents than soda hyposulphite, as when this salt was used it was a risk to use silver and pyro afterwards. He employed potassium cyanide with success at times, but found the films were not always in the proper condition. At one time also he used ammonium sulphocyanide; this had certain drawbacks, and it required a great deal of washing to get rid of it,

but there was a slight gain over soda hyposulphite, as the film did not stain nearly so much on the application of pyro and silver. But with all this it was very slow work, and something was always wanting. He never found the preliminary wash of iodine of much advantage to a gelatine plate; it worked well for wet plates, but not so well for gelatine.

There is another defect that is very vexatious in gelatine plates; that is, some of the plates, especially the larger sizes, have a thin end to them, sometimes owing to the glass not being perfectly flat. With the intensifier about to be proposed, Brooks finds it very easy to get local intensity on such parts in just the same way as we used to do with wet plates, namely, by pouring the developer on and off the place that may require it. He is also able to intensify a mere ghost of an image to good printing density with but very little trouble, providing the shadows are free from deposit and quite clear. The slightest veil in these parts comes up with the image, and a favourable result is not obtained. If the shadows are only slightly veiled, allowing them to remain in the hyposulphite solution for ½ hour may clear them; if not, recourse must be had to other reagents, such as iron perchloride followed by hypo. Care, however, must be taken that its action is even.

Before attempting to intensify the negative, all traces of soda hyposulphite must be eliminated, and there is nothing better for the purpose than the alum and citric acid solution. Make a stock solution, consisting of a saturated solution of common alum, with 1 oz. citric acid dissolved in every 10 oz. After the negative has been *well washed*, place it in a dilute solution of the above (1 part to 4 of water), and allow it to remain for about ½ hour; then place in a developing measure (supposing a half-plate is being operated upon) about 2 dr. of the stock alum and citric-acid solution, and add to it about 2–3 gr. of dry pyrogallic acid. Give it a shake round to dissolve; then drop in 3 or 4 drops of a 20-gr. solution of silver nitrate, and apply to the plate, holding the latter on a pneumatic holder and pouring off from alternate corners. If the film repel the solution, just run the finger or a brush kept (clean) for the purpose over the repellent portion of the film. This is very energetic, and the alum in the solution keeps back any trace of hypo that may be lurking about. It is not satisfactory to work in a dish when intensifying, as the back of the plate gets very cloudy; and sometimes, as the solution gets brown, it apparently discolours the film, but that all comes right afterwards. Silver is added according to the density required. When sufficient density is obtained, well wash and place for about 5–10 minutes in the hypo fixing bath; well wash again, and place in the dilute alum and citric solution. This will remove all colour, and if there were any greenish-yellow look about the negative before intensification it will be found to have all disappeared, and the result is a negative in all respects equal to the finest wet plate. Care must be taken not to work the alum and citric bath too much, so as to foul it with the hypo. (*Brit. Jour. Photog.*)

(2) Notwithstanding the fact that a good deal of attention has been given to the subject of intensifiers, but few photographers are satisfied with the results obtainable with the mercury methods. Arnold Spiller thinks that a perfect intensifier for gelatine plates, as compared with the silver redeveloper for collodion films, does not exist; yet there are several processes, if used with care, that answer well for most purposes, and perfectly in a few cases. It will, no doubt, be of interest to some readers to explain here the difference between the silver solution acting with collodion film and the mercury with gelatine.

In the collodion film, the image is on the extreme surface, and the particles of silver on the film attract the crystalline silver precipitate which gradually separates out from the depositing solution. In the high lights,

where there is a greater conglomeration of silver particles, a larger proportion of metallic crystals are deposited, because the attractive force there is greater. Thus in the intensification of a collodion film the second deposit is in exactly the same proportion as the first, and therefore the delicate gradation of the original image is perfectly preserved after the process of intensification. In the treatment of a gelatine plate with the mercury intensifier, the effect is very different, for the image is not only on the extreme surface, but in the denser parts the deposit is situated throughout the thickness of the film. When treated with the mercury solution, the half-tones and details in the shadows of the negative are at once increased to double their original density, while only the surface of the deposit in the high lights is attacked; therefore the increase in density of the latter is not more than perhaps 20 or 30 per cent., supposing that the negative under treatment only requires a moderate amount of intensification. In such a case, the image greatly loses its brilliant contrast or, technically speaking, a general "flatness" in the resulting photographs is noticeable. This tendency of the mercury intensifier to produce "flatness" may, in some few exceptional instances, be turned to good account, as when a negative possesses too much contrast, but requires a slight strengthening of the image. There is still another example where the mercury solution will, if employed, yield results well-nigh perfect—referring to the intensification of very thin images, as are frequently produced with highly sensitive commercial plates. In this latter case, the silver deposit should be subjected to the action of the mercury till the entire image is attacked—often a matter of 7–10 minutes — when, of course, the negative preserves its original delicate gradation after the process of intensification. By mercurial intensification, is meant the process of bleaching the silver deposit with a mercuric salt, and then treating with some compound capable of blackening the image, such as ammonia, sulphuretted hydrogen, soda sulphite, or ferrous oxalate. The effect of mercuric chloride (the salt usually used) on the silver image is to convert the latter into silver chloride, and, at the same time, to deposit locally mercurous chloride; thus the bleached image consists of silver chloride and mercurous chloride. In the process of blackening, it is generally only the latter that is affected, e. g. ammonia forms the black mercury amido-chloride; while, again, soda sulphite reduces the mercury salt to the metallic state. With sulphuretted hydrogen, or ammonium sulphide, both the chlorides in the image are converted into the corresponding sulphides; also ferrous oxalate reduces the two chlorides to the metallic state.

It is a well-known fact that free acids act as powerful restrainers in preventing the combination of metallic salts with organic substances; as, for example, the use of citric acid in hindering the formation of silver albuminate in sensitised albumenised paper. In the same way, hydrochloric acid prevents the formation of the gelatino-mercury compound. In proof of this assertion, Spiller cites an illustrative experiment. An ordinary gelatine negative was cut in half, one piece was treated with the usual neutral mercuric solution, and the other was immersed in a similar solution, but containing a small proportion of hydrochloric acid; both films were then thoroughly washed in the same dish.

The two plates were next cut up into three, and one piece from each was treated with solutions of ferrous oxalate, ammonium sulphide, and dilute ammonia respectively. On examination, it was found that while all the films that had been immersed in the acid mercury bath presented beautifully brilliant negatives and quite colourless in the shadows, those pieces from the neutral bath were more or less stained. The alkaline sulphide solution developed the most stain, and was of a very non-actinic brown tint; ferrous oxalate yielded a less conspicuous grey deposit,

while the ammonia gave the least objectionable result. It was found, however, that the ammonia-treated film turned quite brown on after treatment with the sulphide solution, proving that the ammonia did not remove part of the mercury, but the latter remained to a certain extent *in embryo*. For the intensification of gelatine films in which a preliminary treatment with mercuric chloride is required, Spiller recommends the following solution :—

Saturated solution of mercury bichloride	20 oz.
Hydrochloric acid (strong)	½ dr.

A larger proportion of the restrainer might be added when treating hard films, but for general purposes the above formula is preferable, as the acid is liable to produce frilling.

Although not generally used, and probably unknown to many, the most perfect method for intensifying gelatine films is that in which a mercury compound is used simply as a carrier for silver, but does not actually exist in the final result. The process to which reference is made depends on the reduction of silver cyanide by a mercurous salt; the film is bleached in a solution of mercuric bromide, and, after slight washing, is immersed in a bath of silver cyanide dissolved in potassium cyanide. By the first treatment, the silver image is converted into mercurous and silver bromides, as is illustrated in the following equation :—

Mercuric Bromide.		Silver.		Mercurous Bromide.		Silver Bromide.
$HgBr_2$	+	Ag	=	HgBr	+	AgBr.

In the second reaction the mercurous bromide reduces the silver cyanide to the metallic state, thus :—

Mercurous Silver Bromide.		Potassic Silver Cyanide		Mercuric Cyanide.
HgBr.AgBr	+	$AgK(CN)_2$	=	$Hg(CN)_2$

Potassium Bromide.		Bromide and Metallic Silver.
+ KBr	+	Ag.AgBr

From the above, it will be seen that the intensified image is composed of metallic and silver bromide, so that should the deposit, after the treatment, be too intense, it can easily be reduced by a bath of dilute hypo, which dissolves the bromide.

The formula which Spiller recommends for intensifying by this process, although possessing little that is novel, may prove of value to many of the readers who have no experience with the method. The following solutions are required :—

(*a*)	Mercury bichloride ..	1 dr.
	Potassium bromide ..	1 dr.
	Water	16 oz.
(*b*)	Silver nitrate	1 dr.
	Potassium cyanide ..	1½ dr.
	Water	8 oz.

The commercial potassium cyanide is quite pure enough for this purpose; but if the pure salt be used, only 1 dr. should be taken. The solution of cyanide should be made at least 24 hours before required, and the liquid shaken briskly from time to time, to ensure the saturation by the silver. Even after standing for the above period, a large precipitate will remain undissolved.

A negative to be treated by this method is first soaked in (*a*) till the image is more or less bleached, according to the amount of intensification required; it is then washed in 2 or 3 changes of water, placed in another dish containing (*b*), and there allowed to remain until the white deposit is blackened throughout the whole film. The latter is finally very thoroughly washed, preferably in running water, for about ½ hour, in order to remove every trace of the silver. Negatives treated by this means ought to be permanent, as the cyanide acts like hydrochloric acid in dissolving out every trace of mercury.

In conclusion, Spiller advises the addition of a small proportion of hydrochloric acid to the mercury bath for all processes in which the chloride *per se* is used; but when expense is no object, the mercuric bromide and silver cyanide is the most satisfactory method for gelatine films. (*Photo. News.*)

(3) The chemical now mostly used in

intensifying gelatine plates is mercury bichloride in combination with ammonia, or potassium iodide or cyanide. The main difficulty of such intensification has been that it was not stable; in a short time the image on the plate, if exposed much to the light, fades out, and spoils the negative. The intensifier given below has been found to work well, and at the same time possesses the quality of being absolutely stable.

(*a*) A stock solution of iron sulphate is made as follows:—

Iron sulphate	15 gr.
Citric acid	15 gr.
Water	1 oz.

(*b*) A second solution is made as follows:—

Water	1 oz.
Silver nitrate	10 gr.
Acetic acid	10 m.

To intensify, take enough of (*a*) to cover the plate, and add thereto 6–10 drops of (*b*); flood the plate, and the intensification will proceed in a clear, gradual, and satisfactory manner. To produce a great degree of intensity, more of the silver solution should be added, a few drops at a time.

(4) Dr. Eder has frequently used the mercuric chloride and sulphite method for intensifying gelatine negatives, and recommends the process.

The washed negative is placed in a solution of mercuric chloride, and allowed to remain a longer or shorter time according to the degree of intensification required. After this, the plate is rinsed with water—a thorough washing being superfluous. To blacken the plate, it is now immersed in a strong solution of sodium sulphite (say 1 part of sulphite in 8–10 of water), and when the darkening has reached its maximum, the plate is well washed.

The special advantage of this method is the fact that there is no necessity to wash away all traces of the mercuric chloride before placing the plate in the sulphite bath, as mercuric chloride and sodium sulphite do not react upon one another. The white and insoluble mercurous chloride which is deposited upon the plate is, however, rapidly reduced to the metallic state by the sulphite. As metallic mercury forms a stable image, negatives intensified by the method described may be regarded as permanent; moreover, the colour is a very good one for printing, and there is but little fear of losing the more delicate shades of the subject from over density.

If the intensification has been carried too far, it is easy to reduce the negative by treatment with a very weak potassium cyanide solution.

(5) W. T. Wilkinson has been experimenting with a new intensifier, which, as its principal ingredient is platinum, induces the hope of greater permanency than the usual mercurial intensifier. The formula stands thus:—

(*a*) Ammonium chloride ..	5 gr.
Mercury bichloride ..	10 gr.
30-gr. solution of platinum bichloride ..	1 oz.
Water	20 oz.
(*b*) Liquor ammonia	½ oz.
Water	20 oz.

Two solutions are given, but it is rarely that more than the first solution is needed.

Immerse the negative to be intensified in (*a*), and watch carefully the action. Directly the requisite density (a dark-brown colour being the result) is reached, remove and wash thoroughly. If, however, through extreme weakness or not stopping exactly at the right time, the image begins to bleach, let it continue until nearly white, and then wash and immerse in (*b*).

For negatives requiring only a small amount of strengthening, this process is splendid; and even when carried out so far as to render the use of 2 solutions necessary, there is no clogging of the shadows or intense yellow films, as is frequently the case with mercury alone. After washing thoroughly and immersing in (*b*), the change takes place very slowly, the high lights gradually assuming a bluish black, and the shadows clearing if the negative be an over-exposed one. This clearing of the

shadows is very valuable, and, instead of having a thick negative taking hours to print, the result is a negative harmonious from high light to clear shadow. All the changes are slow, and under perfect command.

If the negative be in the state best described as *nearly* dense enough, careful washing in the first solution will give just the requisite density, and then a thorough washing and immersion in

Ammonia	1 dr.
Water	20 oz.

will yield a result as perfect as possible. After the ammonia solution has done its work, the negative does not gather any more density, no matter how long it may be left in. One precaution is, however, necessary during both stages, and that is, the dish must be kept gently rocked, or streaks are likely to form. (*Brit. Jour. Photog.*)

(6) The mercury intensifier for gelatine plates, now largely used by photographers, has been somewhat improved by H. J. Newton quite recently. The advantages claimed for it are simplicity, speed, and giving to the negative a good colour. The intensifier, combining mercury, potassium iodide, and sodium hyposulphite, sometimes gives to a negative a yellow colour, which makes it a slow printer. The solution will not keep well, but soon precipitates.

Newton's formula overcomes these objections. He first takes 10 gr. mercury bichloride, pulverises it in a mortar, and dissolves in 10 oz. water. He next dissolves 190 gr. potassium iodide in 3 oz. water, and gradually pours the same into the mercury solution. A red precipitate occurs, but will be redissolved when the whole amount of potassium iodide has been added. The 13-oz. concentrated solution thus formed is now diluted by the addition of 24 oz. water. The intensifier will keep clear for a long time, and so retain its strength.

To intensify, Newton pours a sufficient quantity of the intensifier into a tray, and immerses in the same the dry or dried negative. The action of the intensifier takes place in a few seconds, and the intensification is completed in 2–3 minutes.

The plate is then washed and immersed for a few seconds in a very dilute solution of sodium hyposulphite, again washed, and dried. Negatives in which there was very little detail in the shadows have been very easily brought up to good printing density with this intensifier. It is essential that the soda hyposulphite shall be eliminated from the plate before intensification. To avoid an extended washing for that purpose, Newton quickly dissolves out the hypo from the film by pouring over the latter, after fixing, a solution of 5–10 gr. lead nitrate to the oz. of water. Its action is easily observed by the formation on the film of a milky precipitate, which may be easily washed off.

(7) Dr. Nicol remarks that several of the published methods of mercurial intensification may be relied upon as both safe and practical; but the following, which has been repeatedly described, he believes to be the best:—

(*a*)	Mercury bichloride ..	1 oz.
	Ammonium chloride ..	1 oz.
	Potassium iodide	quant. suff.

Dissolve the mercury and ammonium salts in 10 oz. water, putting them both in together, and add sufficient of a strong solution of potassium iodide to dissolve the red mercury iodide formed by the first additions. Then make up the bulk with water to 20 oz.

(*b*)	Silver nitrate	1½ oz.
	Potassium cyanide	quant. suff.

Dissolve the silver in 5 oz. water and add sufficient of a strong solution of the cyanide to dissolve the precipitate formed by the first additions, and make up the bulk with water to 20 oz. The solutions will keep indefinitely, and, where very much intensification is required, should be used at the full strength; but when only a slight action is desired, (*a*) may be diluted to ½ or ¼.

The fixed and well-washed negative should be placed in a dish with sufficient of (*a*) to cover it, and keep in motion for a few seconds. Let the

action proceed, examining the plate from time to time, till apparently sufficient — or, rather, a little more — density is produced. At this stage the negative will have the appearance of a rather dense but thoroughly good printing collodion image, and the operator may feel inclined to "let well alone." On well washing the plate, however, he will find the whole deposit has assumed a yellow colour, and the washing must be continued till that colour is uniform all over. When that change has been accomplished, the plate must be placed in another dish, covered with (*b*), and kept in motion for a few seconds as before. Gradually, beginning with the higher lights, the yellow will give place to a fine olive brown, and the action must be allowed to continue till the whole negative has assumed that colour. A final wash completes the operation.

Regarding the practical permanence of the image thus intensified, Dr. Nicol has no doubt whatever. He has practised the matter pretty constantly during the last 2 years, and there lay before him while he wrote a negative from which some hundreds of prints had been taken, and it was, so far as it is possible to judge, absolutely unchanged. (*Brit. Jour. Photog.*)

(8) Scolik, of Vienna, has recently experimented extensively with a soda sulphite intensifier, and recommends the following formula :—

(*a*)	Mercury bichloride ..	1 oz.
	Potassium bromide ..	1 oz.
	Water	50 oz.

The above may be diluted 4 times its volume if desired, in order that the action may be gradual and less energetic. The fixed and well-washed negative is allowed to remain in (*a*) until the film becomes well whitened. If a small degree of intensification is desired, it should be left in but a short time.

The plate is next slightly rinsed off (a thorough washing not being required at this point), and immersed in

(*b*)	Saturated solution soda sulphite	5 oz.
	Water	5 oz.

The darkening action will be observed to take place gradually, as in the case when ammonia is used, and will impart a rich brown-black colour to the negative, which should be well washed; negatives thus intensified are believed to be permanent. Dr. Eder describes the following as the chemical reaction which takes place. The whitened negative contains mercurous chloride (calomel), and this is reduced to the metallic state by the sodium sulphite, just as appears to be the case when potassium cyanide is used; thus the method now described may be regarded as analogous with Monckhoven's potassium argento-cyanide method. Mercuric chloride is not reduced in the cold by alkaline sulphites, because stable double salts are formed; still, at a boiling temperature, reduction sets in, the mercurous chloride being first formed, and then the metallic mercury. The above fact explains why it is unnecessary to wash away all traces of mercuric chloride before treating with sodium sulphite.

(9) That not a few of the votaries of the art would forsake mercurial intensification for silver and iron or other permanent redevelopment, were they assured of the absence of abnormal or other stains, may be taken for granted. A. Donald brings forward a method of intensifying gelatine negatives with silver and iron which has rendered good service since the summer of 1880.

The chemicals necessary are identical with those used with wet collodion, with the exception of the chloro-iodo bath, which apparently decomposes the active principle or constituent in the gelatine that causes the well-known pink fog. Neither iodine nor sodium chloride by itself will prevent the pink stain, but a combination of both as prescribed. The image is, probably, converted into silver iodide, which in turn gives place, to some extent, to the excess of chloride, forming both iodide and chloride of silver in the film, and during the decomposition the fog-producer is destroyed or rendered harmless. At all events, the negative is very

readily and successfully intensified after its immersion in the bath.

The following are the requisite solutions: (*a*) saturated solution of common salt; (*b*) ruby solution of iodine in potassium iodide; (*c*) 10-gr. solution of iron protosulphate; (*d*) 15-gr. solution of silver nitrate; (*e*) a very weak solution of potassium cyanide.

When the crystals in solution (*d*) are dissolved, a few drops of a saturated solution of soda carbonate should be added, and the bottle placed in the light until clear. The silver should then be filtered and acidified with acetic acid (eschew nitric) enough to turn litmus paper red. To solution (*c*), ½ oz. glacial acetic acid must be added to every 15 oz. water. Test a mixture of (*c*) and (*d*) thus: Pour into a developing cup ½ oz. of (*c*), and add (say) ½ dr. of (*d*). If the combination turn muddy in less than 5 minutes, add more acetic acid to the stock bottle (*c*), until it remains clear when mixed with the silver solution for the specified time.

To intensify the negative: It is premised that the negative has been "alumed" and washed thoroughly to free it from the fixing agent. If the film be tender it is best, in the first place, to dry it. Now pour into a clean measure sufficient of (*a*) to cover the plate; then add a few drops of (*b*), until the colour of amber be attained. Immediately place the negative in a clean tray, and pour over it the chloro-iodo solution. Leave the plate in this bath for 4–5 minutes—the thicker the film the longer it should remain—then well wash it under the tap. As vegetable and other extraneous substances from the washing-water often adhere tenaciously to the surface of the film, thereby causing irregular markings, at this stage any such should be gently removed by a tuft of cotton wool dipped in water.

The next operation must be done in the dark room—one in which wet collodion can be worked—or by candle- or gas-light. To proceed: into a developing cup shake a few drops of (*d*), and add (say) for a half-plate almost ½ oz. of (*c*). Flow this on the negative, and let it remain for 3–4 minutes—not longer—gently rocking the plate the while; then quickly place it under the tap until all greasy lines have disappeared. It will now be seen that a considerable increase of density is the result. One operation generally suffices; but if the image be still too thin, clean out the cup and repeat the dose. The plate will be thin, indeed, if it requires a third application. After a good wash, place the negative in solution (*e*) for 1–2 minutes, when it may be examined in daylight. Well wash again, then dry, and varnish.

If ordinary precautions be taken with the above method, there will be little fear of red fog; but if, from inadvertence or other cause, it should appear, immediately immerse the negative in a fresh solution of (*a*) and (*b*). It has the valuable property to a great degree of clearing off the stain. Should the fog be deep and obstinate, place *out of doors* the plate in a solution of potassium sulphide, when it (the stain) will gradually vanish. This treatment intensifies the negative. It simply requires to be well washed in running water, dried, and varnished. (*Brit. Jour. Photog.*)

(10) Abney's method for increasing the sensitiveness of the ferrous-oxalate developer. Add 10–40 drops, according to requirement, of a 25-gr. solution of hyposulphite to 3 oz. of developer.

(11) Cowell's Clearing Solution.

Alum	2 parts
Citric acid	1 part
Water	10 parts

Edwards makes this sherry-coloured with iron perchloride.

Stripping Film from Negatives.—Frequently inquiries are made as to the best means of removing a gelatino-bromide negative from its glass support, so that it can be used either as a direct or reversed negative, and it does not appear to be very generally known that a few years ago Pl'oner described a method which answers well under all circumstances, whether a substratum has been used or not.

If a negative is immersed in extremely dilute hydrofluoric acid contained in an ebonite dish, say ½ teaspoonful to ½ pint of water, the film very soon becomes loosened, and floats off the glass, this circumstance being due to the solvent action which the acid exercises upon the surface of the plate as soon as it has penetrated the film. If the floating film be now caught upon a plate which has been slightly waxed, and is allowed to dry on this plate, it will become quite flat and free from wrinkles. To wax the plate, it should be held before the fire until it is moderately hot, after which it is rubbed over with a lump of wax, and the excess is polished off with a piece of flannel. When the film is dry, it will leave the waxed glass immediately, if one corner is lifted by means of a penknife. The film will become somewhat enlarged during the above-described operation; but, by taking suitable precautions, this enlargement may be avoided. It is also convenient to prepare the hydrofluoric acid extemporaneously by the action of sulphuric acid on sodium fluoride; and, in many cases, it is advisable to thicken up the film by an additional layer of gelatine.

The following directions embody these points. The negative, which must be unvarnished, is levelled, and covered with a layer of warm gelatine solution (1 in 8) about as thick as a sixpence. This done, and the gelatine set, the plate is immersed in alcohol for a few minutes in order to remove the greater part of the water from the gelatinous stratum. The next step is to allow the plate to remain for 5–6 minutes in a cold mixture of 1 part sulphuric acid with 12 of water, and in the meantime 2 parts sodium fluoride are dissolved in 100 of water, an ebonite tray being used. A volume of the dilute sulphuric acid equal to about ¼ of the fluoride solution is next added from the first dish, and the plate is then transferred to the second dish, when the film soon becomes liberated. When this is the case, it is placed once more in the dilute sulphuric acid. After a few seconds it is rinsed in water, and laid on a sheet of waxed glass, complete contact being established by means of a squeegee, and the edges are clamped down by means of strips of wood held in position by clips or string. All excess of sulphuric acid may now be removed by soaking the plate in methylated alcohol, after which it is dried. It is as well to add a few drops of ammonia to the last quantity of alcohol used.

The plate bearing the film negative is now placed in a warm locality, under which circumstances a few hours will suffice for the complete drying of the pellicular negative, after which it may be detached with the greatest ease by lifting the edges with the point of a penknife. (*Photo. News.*)

Remedy for Frilling.—(1) The tendency of the film on gelatine plates to "frill" and rise up off the glass during development is very common when the solutions are warm. A remedy described by Watmough Webster, which, in his experience, has proved to be valuable and useful, is as follows. After the frilled negative has been fixed, it is washed a few minutes, and then immersed in an alum solution for 1 hour; it is again washed and soaked for 12 hours—overnight, for instance—in a dish containing alcohol; the dish should be covered with a sheet of glass to prevent the evaporation of the alcohol. At the end of 12 hours the frilling or blistering will have entirely disappeared.

(2) Soak the plate before development in a saturated solution of Epsom salts (magnesia sulphate); wash and develop as usual.

Putting up Plates. — At a recent meeting of the New York Society of Amateur Photographers, Newton called attention to the danger of the injurious action of soda hyposulphite, contained in the dividing paper frames, upon gelatine plates as they are at present put up and sold. He exhibited several specimens in which the deleterious action of the chemical was distinctly visible. The general effect was to fog the edge,

and frequently the whole of the plate, and thus seriously injure it for future use. As a remedy, he suggested that the plates be packed in tin or metal boxes, or that the division frames be varnished or shellacked, which would in a measure counteract any injurious effect of the chemicals contained in the paper.

Reducing Negatives.—(1) F. C. Beach presented the following formula for reducing negatives :—

(*a*) Water	15 dr.
Gold chloride	15 gr.
(*b*) A Weak Solution of Potassium Cyanide.	
Water	8 oz.
Potassium cyanide ..	10 gr.

The plate to be reduced is soaked in water for a minute, and is then flowed over with (*a*) for ½ minute; it is then washed, and flowed with the cyanide solution. The reduction takes place gradually, and if the first application is insufficient, the operation should be repeated.

(2) A formula given by Newton is as follows :—

Water	10 oz.
Copper sulphate ..	100 gr.

After the copper is dissolved :

Potassium bromide ..	100 gr.

are added, which converts the solution into copper bromide.

Then 1 oz. of the above is added to 2 oz. water; the plate is soaked in this for a minute or two, washed, and put into a weak solution of soda hyposulphite for 2–3 minutes, and again washed. The manipulation may be repeated should the reduction be insufficient. The copper solution may be used over and over.

(3) Another solution is :—

Water	1 oz.
Iron perchloride solution, as obtained at the druggists'	½ dr.

The plate is laid in this for 2–3 minutes, washed, put into a weak solution of hypo for the same length of time, washed, and dried.

(4) It is often observed that there is no satisfactory method of reducing mercury intensified negatives. This assertion requires qualifying. When the silver cyanide method is adopted, the mode of operation is extremely simple. The only danger is of overdoing it, and allowance must be made for the difference between a gelatine negative when in a wet and a dry state.

If a negative be too dense when removed from the silver cyanide bath, flow over it a weak solution—say 2 oz. of a saturated solution to 1 pint water—of soda hyposulphite. The action which follows is a rapid one, and a second or two sometimes suffices to produce the requisite effect. Water should be handy, into which the negative should immediately be plunged and well rinsed before examining it. It will now be found more harmonious, and the colour unchanged, excepting in so far the now thinner film. If the reduction be insufficient, the operation can be repeated. The negative requires, of course, to be well washed afterwards to free it from hypo.

As to the keeping qualities of negatives so reduced, if the primary operations of fixing and thorough washing be properly performed, there is no difference from other negatives not so treated.

Should a negative that has been intensified and varnished be found to give hard prints, the varnish can be removed, and the operation of reduction performed in a similar manner. To remove the varnish, flow over the negative sufficient methylated spirit to cover it. Allow the spirit to remain for a little to penetrate the varnish. Drain on to a tuft of cotton wool, then gently polish, so to speak, the face of the film. Once more flow with spirit, and clear off with a soft piece of clean linen rag. Afterwards immerse in water, when any gum still adhering is easily removed, and the negative is ready to be reduced. (A. Donald.)

(5) A formula given by Dr. Janeway consists in dissolving 9 gr. potassium ferricyanide (red prussiate of potash), by stirring with a glass rod, in 3 oz. of

a 5 per cent. solution of soda hyposulphite, which is sufficient to cover a 5 × 8 plate, and should be mixed on the day it is used. The action of the reducer is quick, and careful watching is necessary. With a camel-hair brush, which has been dipped in the solution, dense portions of a dry negative may be touched over and reduced. Care should be taken to wash off the plate after each application.

Toning Silver Citro-chloride Prints and Transparent Positives.—The probabilities being in favour of an increased use of silver citro-chloride mixed with gelatine, for the purpose of obtaining positives printed out for enlarging, the lantern, opal, or paper, it may not be considered out of place to say something about the prints so obtained. Not that the ordinary methods of toning paper prints are unsuitable, or that any very especial care need be observed beyond the usual precautions; still, without some definite formulæ for guidance, there is a possibility some difficulty may be experienced in obtaining the colour desired.

The following will be found capable of giving any tone to the transparency or positive by reflected light, ranging between warm brown and purple black:—

Ammonium sulphocyanate	1 dr.
Water	1 pint
Gold terchloride	1 gr.

Upon adding the gold, it is converted into a sulphocyanate, which will be seen to have a red colour. The precipitate, however, dissolves in the excess of sulphocyanate, and is then ready for use.

Washing before toning is dependent on the formulæ employed in making the emulsion; in most cases it will be found advisable. Toning action is first seen at the edges, by the colour changing to a yellowish brown; soon the whole print assumes a sepia tint, then purple, and finally blue-black, the usual time occupied in these changes being less than 5 minutes. The print should then be transferred to another dish containing a plain solution of ammonic sulphocyanate (2 dr. of the salt in 1 pint of water), where it may remain 5–10 minutes, after which it should be placed in weak hypo (1 : 10) until the soluble chloride is dissolved. Ammonium sulphocyanate alone will be found to fix a plate or paper print made with silver citro-chloride emulsion, but hypo is cheaper and quicker. Should the plates or paper be inclined to frill, place them in saturated chrome alum solution after toning; this in no way affects the colour or purity of the whites. Washing is the same as with other gelatine plates and silver prints. (W. M. Ashman.)

Drying Plates.—(1) An inconvenience which has caused no little trouble to workers with gelatine plates is the length of time they take to dry. A collodion plate can be held to the fire and dried in a very short time; but a gelatine plate under the same conditions would melt and run. Now, a gelatine plate may, under different conditions, be dried quite as rapidly as a collodion plate; it is possible to take a negative, dry it, and print a proof in considerably less than ½ hour.

The principle is simply to remove the superfluous moisture before holding the negative to the fire, and this can be done by applying a piece of perfectly clean blotting-paper to the surface of the gelatine, using at first a moderate pressure, and increasing this pressure to any degree required. The blotting-paper will in *no way* injure the negative, and any stray pieces of fluff will dust off when the plate is dry. Still, it is better to carefully dust the blotting-paper, and to remove any stray pieces of material before it is applied. It will now be found that the negative can be dried at any degree of heat in the space of ½–2 minutes. This fact led to the following:—

If a gelatine negative be dried as above, at only a moderate heat, it will not perceptibly differ from a negative which has been allowed to dry spontaneously; but if a negative from which the superfluous moisture has been extracted by blotting-paper be exposed to a greater heat, the whole complexion of

the negative is altered. Not only does the film become horny and tough, but the picture on it appears in *relief*—so much so that it seems quite possible to produce a cast from the negative capable of being printed from in an ordinary press. This is an extension of the principle in which hot water is used as a *developer;* but this latter does not seem either as simple or efficacious as the method suggested. (J. J. S. Bird.)

(2) After well washing, place the plate in a bath of methylated spirit for 2–3 minutes; afterwards flow 2 or 3 times with common methylated sulphuric ether. The negative will dry in a current of air in 2–3 minutes.

(3) Drying cupboards will be found described and illustrated in the article on Desiccating, pp. 108–111.

Gelatino-bromide Film Paper.—(1) Since the discovery and rapid development of dry-plate photography, many attempts have been made to dispense with the use of glass as a support for the film, and so far with considerable success. One of the most promising inventions of the kind is that of Thiébaut, a photographer, of Paris. It consists in the preparation of a gelatino-bromide of silver film paper, from which the film can be detached in a dry state after exposure and development. The advantages are that the sensitive coating is regular, and its thickness is uniform throughout the entire surface; it can be exposed for a luminous impression in any kind of slide, and it can be developed and fixed as easily as a negative on glass. Further, the negative dries quite flat on blotting-paper, and the film being without grain, the negatives are as fine and as transparent as those upon glass. The negatives can be printed from either face, which is of advantage in connection with phototypy and photo-engraving. The manufacture is carried out in the following manner:—

A gelatinised sheet of paper is damped with cold water, and when evenly saturated it is placed on a glass, to which it is attached by means of bands of paper pasted partially on the glass and partially on the edges of the sheet; in this state it is allowed to dry, and is stretched quite flat. The dry sheet is then coated with a solution of ordinary collodion, containing 1–2 per cent. of guncotton (1½ per cent. gives very good results), and 1½–2½ per cent. of castor oil (2 per cent. gives very good results); this coating is allowed to dry.

The glass with the prepared paper upwards is levelled, and then it is coated in a room from which all but red rays of light are excluded, with a tepid emulsion of silver bromide to the extent of about 1 millimeter thick, and after leaving it in this position until the gelatine has set, say about 5 minutes, with the film paper still attached, it is placed upright in a drying room, where it should remain about 12 hours exposed to a temperature of 62°–66° F. (17°–20° C.).

The film paper is detached from the glass ready for exposure, development, and fixing in the usual manner; for the purpose of developing, iron oxalate or pyrogallic acid answers equally well. For the purpose of fixing, a mixture by weight of 100 water, 15 soda hyposulphite, and 6 powdered alum, produces excellent results. After being allowed to dry, the film is peeled off the paper by hand, and can be immediately used for producing negatives.

(2) Warnerke gives the details of a discovery he has made respecting the action of pyrogallic acid on gelatino-bromide. This discovery consists in the fact that a gelatine plate submitted to pyrogallic acid becomes insoluble in those parts acted upon by light, exactly in the same way as gelatine acted upon by chrome salts, the insolubility being in proportion to the amount of light and the thickness of the gelatine. This property Warnerke proposes to utilise in various ways. The drawback in the ordinary gelatine process being that, unless the exposure is very accurately timed, there is considerable danger of over-exposure, and intensification being very difficult, pictures by the gelatine process are often inferior to those by collodion. By the new process he is, however, able not only to intensify, but also to overcome the drawbacks arising

from over-exposure. The latter he effects by using the emulsion on paper. He has found that no matter how much the paper is over-exposed, the picture, provided the developer is restrained sufficiently, is not injured, while in the case of the emulsion on glass, there is not only halation of the image, but a reversal also. The transfer of the image from paper on to the glass is very easy. The paper is immersed in water, and placed in contact with a glass plate. The superfluous moisture being removed by a squeegee, the paper may then be stripped off, leaving the gelatine on the glass. Hot water is then applied, which dissolves all the gelatine not acted on by light, and the image is left upon the glass in relief. Intensification is effected by mixing with the emulsion a non-actinic colouring matter, and which is not affected by silver. Aniline colours answer the purpose, and in this way special emulsion for special purposes can be prepared. This method of preparation would be especially suitable for magic-lantern slides. Warnerke claims that by his discovery relief can be obtained far more easily than by the ordinary bichromatised gelatine, and therefore it is especially suitable for the Woodburytype process. By mixing emery powder with the emulsion, it is rendered fit for engraving purposes, and by a combination with vitrified colours the image can be burnt in, and being so adapted for enamels. By using a suitable emulsion, however, so little gelatine can be employed as to obviate all difficulty in carbonising. The process can also be adapted for collotype printing. The sensitive paper can be used in the camera in lengths, wound on rollers.

Tissue Negatives from Plates.—The method of removing the films from collodion plates by means of a coating of transfer collodion, and subsequently either remounting them upon the glass in a reversed position to be utilised in processes requiring "reversed negatives," or preserving them as "tissue" negatives, in which form they may be printed from either side, will be familiar to most readers. The application of the process to gelatine plates presents somewhat more difficulty. Following are a few particulars of the treatment found by Wilfred Bailey successful.

The collodion is prepared from one of the usual formulæ for the purpose, as follows: Ether, 5 oz.; alcohol, 0·805, 10 oz.; castor oil, ¼ oz.; pyroxyline, ¼ oz.

The gelatine negative (in a dry, and, of course, unvarnished condition) is flowed liberally with the collodion, levelled, and allowed to dry. The film is then cut through to the glass at a short distance from the edges, and the plate is left to soak in water for some 24 hours, after which it will be found that the film may be lifted by a corner, and easily detached from the glass. It may then be reversed, and laid upon the glass under water in a similar manner to that adopted with carbon tissue, the superfluous water being afterward gently pressed out, care being taken not to injure the gelatine surface, which is somewhat tender at this stage. The plate should then be allowed to dry (not too quickly, or the film will have a tendency to peel off the glass). If only a reversed negative is wanted, it is now ready for use; but if a tissue negative is desired, the plate should again be flowed as before with the collodion, dried, cut round, either at the edges where previously cut, or to any size and shape desired, and then soaked in water until it can be easily removed from the glass, which will be the case in a few minutes. The film may then be dried in blotting-paper, and preserved between the leaves of a book (one interleaved with tissue paper will be found convenient for the purpose).

To print, the film may be laid upon a piece of glass in the printing frame, and will be found to lie flat without difficulty in a dry state; but, if desired, it may be mounted as before with the aid of water, and dried. In the latter case, it will be generally found necessary to soak the plate a few minutes in water when the film is to be removed from the glass. In all stages of the process where

soaking in water is required, be careful to continue it long enough, as if any adhesion exists between the film and the glass, damage to the former will ensue on attempting to remove it.

Bailey was led to employ this method chiefly for the purpose of printing negatives by the single transfer carbon process, which he considers the best and most convenient (for an amateur especially) that exists, but he finds also great advantage in the small space occupied by the tissue negatives, and their portability. The tissue is very tough, and cannot easily be torn (unless a cut or tear has begun at the edges, in which case great care is requisite). The second coating of collodion acts as a protection to the enclosed gelatine film, and adds substance to the tissue, while it prevents the "cockling-up" which the sensitiveness of the gelatine to moisture causes if it is attempted to use the film as a tissue on its first removal from the glass, without a second application of the collodion as directed. Of course the same treatment may be applied to transparent positives, and might be useful for other purposes. (*Photo. News.*)

Hartley's Dry-plate Process.—Sensitiveness of a gelatine emulsion depends upon the fineness of the silver bromide in the gelatine; the finer it is, the more rapid. Weak solutions give finer precipitates than strong solutions. Acid solutions give finer precipitates than alkaline solutions. Some have said that the sensitiveness of an emulsion depends upon its being more or less alkaline—the more alkaline, the more rapid—therefore they use ammonia to make it alkaline. Now, ammonia partially dissolves the silver bromide, making it finer, therefore more rapid. It is not because it is alkaline. Anything that will dissolve the silver bromide and not decompose the gelatine, whether it is acid or alkaline, will do the same thing. By boiling an emulsion, the heat partially dissolves the silver bromide. The more bromide that is used in excess of what it actually takes to precipitate the silver used, the less boiling it will take, because the excess of bromide will dissolve the silver bromide, and the heat will hurry it along. The more acid an emulsion, the longer you can boil; the more alkaline, the shorter time, as the ammonia aids in dissolving the silver bromide.

All know how to make ammonia-nitrate of silver, by adding ammonia to a silver solution until the silver oxide formed has redissolved. Hartley tried this with silver bromide, and found by adding ammonium bromide or potassium bromide to a precipitate of silver bromide, that the excess would redissolve the silver bromide, making a clear solution, same as excess of ammonia redissolves the silver oxide in making silver ammonia-nitrate.

When the silver bromide is all redissolved, it is in the finest possible state of division. He added this to the gelatine, which makes a clear, transparent mixture, and when he began to wash it, it began to emulsify. The longer he washed it the quicker it would work. A trial proved that it was too rapid, and the plates would have to be made and handled in absolute darkness in order to work them successfully. Besides, the silver bromide added to the gelatine in this state decomposed it, so that it was difficult to get it to set. He therefore got his fineness of silver bromide by the same theory, but in a different way.

The intensity of a negative depends upon the proportion of silver to the gelatine. The more silver, the less intensity and more detail. ½ gr. silver to each grain of gelatine will make a very intense negative, while 2 gr. silver to every grain of gelatine will make a very thin but full detail negative. When gelatine is boiled, it refuses to set without a cooling slab; and when not heated above 140°–150° F., and then only long enough to flow the plates, they set and dry without any trouble.

It is not necessary to use the gelatine so thick as recommended in published formulas (namely 30 gr. to the ounce), as it takes longer to set and dry, and is

a waste of emulsion, as intensity can be regulated by the proportion of silver to the gelatine, and not by the thickness of the film. A gelatine solution, when acid and in a jelly state, will hold 200 per cent. of silver, and when it is alkaline it will hold sometimes not more than ½ gr. of silver to each grain of gelatine; this depends upon how alkaline the gelatine is. Driffield states that gelatine in a jelly state will hold but a small amount of silver, and then only as a sponge holds water; that if you attempt to cut or squeeze it, the silver comes out in solution. This is only the case when the gelatine is alkaline and never when acid. Acid gelatine will hold 200 per cent. of silver, and can be cut or squeezed without danger of losing a drop of silver.

Silver bromide formed from alkaline solutions is not as fine as when formed from acid solutions; and the weaker the solution of bromide, the finer the precipitates of silver bromide. Pure silver bromide is not sesitive to light, but only becomes so when in combination with organic matter, such as gelatine gives to it.

Formula.—Take any hard gelatine—Swiss or Heinrich's—soak it for 12 hours in water, changing the water 3 times during the 12 hours. Do not cut it up. Take it out of the water and lay it on clean paper to dry. No matter how much of this you fix in this way, as when dry it will keep as before.

Take 75 gr. soda carbonate (not bicarbonate) and 60 gr. citric acid, and put into 3 oz. warm water in a quart pitcher; when the citric acid and soda carbonate are dissolved, and all effervescence ceases and carbonic acid gas has passed off, add 16 oz. cold water and 720 gr. of the soaked and dried gelatine and let it stand 30 minutes; now dissolve 720 gr. silver (prepared according to formula given) in 6 oz. water. Place the pitcher containing the gelatine in hot water—do not let the temperature exceed 110°.

When the gelatine is all dissolved, which will take about 15 minutes, add the silver solution to the warm gelatine; rinse out the vessel you dissolve the silver in with 2 oz. water, and add it to the gelatine solution; when the silver is added, it will immediately turn white (if it turns brown, the gelatine is not good, and must be discarded). Stir well. Now take a bowl large enough to hold the emulsion, wax it inside with beeswax, being careful not to leave an excess of wax; this is to keep the emulsion from sticking to the bowl. Pour the silvered gelatine into the bowl, and set away in a temperature of 40°–60° F. to set.

When this becomes a jelly, which will take about 4 hours, cut it into strips about ¼ in. square, using a silver knife or horn spatula. Put strips of silver gelatine into a half-gallon pitcher, put pitcher into the washing box (described hereafter), put on cover and pour the following solution through the pipe into the pitcher on to the gelatine:

Soda carbonate	150 gr.
Ammonium bromide ..	720 gr.
Alcohol	4 oz.
Water (about 60°–70° F.)	12 oz.

Stir this every ½ hour for 2 hours. When you stir it, take washing box into dark room, shut the door, and by red light only take off the cover; give it a good stirring with a glass rod and replace the cover. To tell when the silver is all formed into silver bromide, take a small piece of the jelly to the light and cut it in two; if it is all alike, the action has taken place, if it is not the same colour all the way through, there is still free silver present. Do not put the piece back into the pitcher, as it would fog the balance. When the silver has all been formed into silver bromide, the emulsion could be washed, melted, and plates prepared, but they would be slow. Now leave the emulsion standing in this brine of ammonium bromide, &c., from 1–5 days or more, according to rapidity you want: 3 days makes a rapid plate, 5–6 days makes a very rapid plate. The reason of this is the excess of ammonium bromide partially dissolves the silver bromide. The longer it remains in the brine, the finer it becomes; also, the weaker the brine, the finer the

silver bromide. But by making it weaker than is recommended here takes too long for the silver bromide to form.

Washing the Emulsion.—Let the water run through the tube to bottom of pitcher and off at faucet below. To tell when the emulsion is sufficiently washed, take some of the waste water running from the faucet into a 2-oz. bottle and add a few drops of silver solution; there will be a precipitate of silver bromide. In an hour take some more of the waste water, and add a few drops of silver solution, and if there is no precipitate of silver bromide, the emulsion is washed enough. If there is still a precipitate of silver bromide, continue to wash until, upon trial, there is no precipitate formed. Stirring the emulsion several times will hasten the washing. Never take off the cover to the washing box, except in red light after you add the brine.

The emulsion is now ready to be preserved for future use, or to be used at once.

To use at once, tie a piece of coarse canvas over a large bowl, pour the emulsion on to canvas and let it drain free of excess of water; put back into pitcher and place into hot water in apparatus described hereafter. Melt at a temperature of 140°–150° F. Add 2 oz. alcohol and 2 oz. pure albumen. (To prepare the albumen, beat the white of eggs to a stiff froth and set aside to go back to liquid.) Add 2 drops of a saturated solution of chrome alum in water to each ounce of emulsion: this is to keep the gelatine from frilling. There should be 35 oz. of emulsion when finished; if not, make up with water. Make smaller quantities in proportion.

Flowing the Plates.—Filter the emulsion through a piece of moist flannel in the glass funnel, placed in the tin funnel as described hereafter; filter into a small pitcher that will hold about 6 oz. You can have several of those small pitchers in hot water; as you empty one, you can be filtering more while you use the others. The small pitchers are for flowing out. Have your plates cleaned as described hereafter, and have them about as warm as when you varnish. Hold the plate with the left hand, the long way towards you, pour some emulsion on the centre of plate, let run to the farther right-hand corner, then to farther left-hand corner, then to corner you have hold of, and off at the nearest right-hand corner; leave sufficient on the plate to make a rather opaque film. Practice will guide you how thick to have them. If they come out too intense, you have too much on: if too thin, you have not enough on. Move the emulsion on the plate until it is smooth, and then place upon screw-eyes as described hereafter. When you have 6 flowed, the first one will be ready to put upon a rack to dry. As soon as a plate is coated, it must be put in a dark place to dry—not even a red light should get to the plates after they are flowed. The place you put them to set should be shaded from all red or white light; a dry plate on a negative exposed for 5 minutes to a red light will make a transparency; so, of course, will fog if exposed too long to red light in making and drying. The plates will dry in a few hours and are ready for use.

The alcohol and albumen are added to hasten the setting and drying, and to aid in the flowing. Gelatine and albumen flow more readily than gelatine alone; the albumen also helps to keep the silver in suspension in the gelatine.

Keeping the Emulsion.—Take the emulsion strips and put them into a wide-mouth fruit jar; pour enough alcohol on to cover the emulsion, screw on the top, and the emulsion will keep. When you wish it, take up what you want to use, wash it to free it of alcohol, let drain and melt. Add albumen, alcohol, and chrome alum as before, and flow the plates.

If you are in a hurry and do not wish to wait the 3–5 days to gain rapidity, you can take emulsion as soon as all free silver has been formed into silver bromide. Melt the emulsion, heat to 140°–150° F. (60°–66° C.), add 480 gr. potassium bromide, and let stand

in the water at 140°–150° F. for 30 minutes. Put aside in temperature of 40°-60° F. (4°–16° C.) to set, and then wash and flow the plates. But if this way is chosen, the emulsion must be washed in a different way than described above, as the soluble ammonium nitrate left in the emulsion will not wash out as in the other process of washing. When the silver bromide is formed in the gelatine, by placing the silvered gelatine in the brine the emulsion does not take up the soluble ammonium nitrate, so only needs sufficient washing to free the outside from the ammonium nitrate. But in the latter case the ammonium nitrate is all through the emulsion, and must be treated as follows:—Squeeze the set emulsion through a piece of coarse canvas into a large bowl of water, take another large bowl, tie a piece of coarse canvas around the top, pour emulsion and water on to the canvas, so as the water will filter off, take emulsion with a silver spoon off of the canvas into another bowl of water; wash this way 3 times, let drain, melt, add the alcohol and albumen as before stated, and flow the plates.

Preparing the Silver.—Put a quantity of silver nitrate into an evaporating dish on a sand bath, with a small amount of water; add to every pound of silver about ½ the white of an egg; fuse the silver until it has melted and run back to an oily liquid; take it off the fire, cool and granulate. This silver is just right for making emulsions, also for making baths by the wet process, and will work in ⅓ the time of any other way of fixing silver.

Washing Box.—Take a wooden pail, make a light-tight cover for it; put near the bottom a good-sized wooden faucet; make out of galvanised iron a ½-in. tube, with 3 right angles in it, to keep light out, and on top a small funnel of same material; insert this tube near the top of wooden pail; let tube extend into pail about 2 in., and connect a rubber hose to the tube that will reach to the bottom of the pitcher containing the emulsion. The brine can be poured into the funnel, through the tube, on to the emulsion, and when ready to wash, let water run into the funnel, through the pitcher, and off at the faucet below.

Melting and Filtering the Emulsion.—Make a tin box 18 in. deep, 12 in. high, 12 in. wide, all sides enclosed except one. On the side that is not enclosed, make flange 6 in. wide all round the opening. Cut a hole in the partition where you intend flowing your plates, large enough to admit this box, let the flange fit up against the partition tight, so as not to admit any light. Put an oil stove in this box. It can, by this means, be lighted and turned out without letting light to the plates, and the stove gets what air it needs from the room not used for flowing the plates. Also this plan keeps the smoke from the flowing room.

Make a tin dish 14 in. long, 8 in. wide, and 3 in. deep. In one end fasten a tin funnel in which a glass funnel holding a pint can be put. Rivet this dish upon top of a tin box, leaving about 2 in. of the end, where the funnel is, extending over the side of tin box, so as to set flowing pitcher under funnel in filtering the emulsion. Put water in this dish and keep it at 140° F. (60° C.), while flowing the plates. Set the pitchers containing emulsions in this water. Use a dipping thermometer to tell when the temperature is right. The hot water will be around the tin funnel and keep the emulsion hot while it is filtering. Use a good-sized oil stove, so as to be sure and keep the temperature at 140°–150° F. (60°–66° C.), while filtering and flowing.

Levelling Slab.—Screw in top of tables or shelf 3 screw-eyes for each plate; level plates by means of spirit level. In very hot days or climates, it may be necessary to have underneath the shelf a zinc-lined drawer in which ice can be placed; in this case, the shelf above the drawer should be lattice work.

Another formula.—There is another way of working this formula which some might prefer. Take the silvered gelatine, heat it to 150° F. (66° C.), add the alcohol, albumen, and chrome alum,

and let set as before described, but not get dry. Make a bath as follows:—

Ammonium bromide	.. 720 gr.
Soda carbonate	.. .. 160 gr.
Alcohol	4 oz.
Water	12 oz.

The alcohol in this formula is not absolutely necessary; but when all water is used, it takes longer to get the silver bromide to form. If you do not use the alcohol, employ water instead, and leave the plates in brine longer.

Put this bath into a grooved box the size of plates you wish to make, put the silvered plates in the ammonium bromide bath and let set 24 hours; take them out, put into another grooved box and wash, put them on rack to dry, and they are ready to use; or they can be used wet, but they will be slower.

Developing.—Any developer that will work on any plate will work on Hartley's the same. But he claims that all published developers given by dry plate factories are right if the exposure is. Unless the exposure is right, or nearly so, a failure is almost sure to occur. Hartley's plan of developing, while using the same chemicals, is on a different theory, making the developer suit any exposure, no matter how long. It is impossible for any one to so accurately judge the time needed as to suit a standard developer; he must make the developer to suit any exposure, and by the following plan you can take any number of plates and not know the time of exposure or amount of light on subject at time of exposure, and if there is plenty of time, no matter how much, you can make a nice negative by this plan of developing.

Pyrogallic acid is used to give strength to the negative, and should be according to the amount of silver in the emulsion. The smaller the quantity of silver, the smaller the quantity of pyro. The more silver, the more pyro. If more pyro is used than should be for the amount of silver, there will be green fog; if the proportion is right, the plates will be clear in the shadows and no green fog.

The ammonia is used for detail. The bromide is used to correct over-exposure. Citric acid is used to keep the pyro from oxidising.

(*a*)	Pyrogallic acid	3 gr.
	Citric acid	1 gr.
	Water	1 oz.
(*b*)	Ammonium bromide ..	48 gr.
	Ammonia	3 oz.
	Water	3 oz.

Take enough of the pyro solution in your developing tray to well cover the plate; let it remain in this solution for a few seconds; put 2–3 drops of the ammonia solution into your developing cup; pour pyro solution out of dish into cup containing the ammonia, then pour contents of cup on to the negative; in a few seconds the image will begin to appear. Repeat the operation of adding the ammonia, drop by drop, until you get all the detail out.

Remember that the pyro gives the strength; the more pyro, the more strength; the less pyro, the less strength.

Ammonia gives the detail: the more time, the less ammonia. Therefore, if you take plenty of time and commence with very little ammonia, you will get a fine negative. Always commence with not more than 2 or 3 drops of ammonia solution, then, no matter what the time is, you have the plate under control. It takes about 5 minutes to develop a dry plate properly. If you use the oxalate developer, use it on the same theory as the pyro. Oxalate in the place of pyro; iron in the place of ammonia; only you must add the iron to the oxalate—not the reverse. Oxalate gives the strength and iron the detail. If you commence slow, you need not use any bromide in either case. As bromide is only used to correct over-exposure, it takes off part of time, the same as when it is not washed out of the emulsion. Fix in hypo and wash as usual.

List of Articles needed. — Washing box; heating box, for melting and filtering emulsion; dipping thermometer; oil stove; racks, for drying; Swiss or Heinrich's gelatine; Hartley's silver; ammonium bromide; pure soda carbonate; citric acid; alcohol; chrome alum;

one quart pitcher; one quart bowl; half-gallon pitcher; one gallon bowl; several small pitchers, for flowing; silver knife or horn spatula.

Cleaning and Preparing the Glass.—Soak the glass in lye, well wash, and put into strong nitric acid; wash and albumenise same as in the wet process, using the albumen a little thicker. Do not add any ammonia, use a few drops of nitric acid instead.

Another way—Rub the glass over with the following solution: Soda silicate, 1 oz.; water, 30 oz.; rub dry with tissue paper.

Another way is to use the glass without any substratum. This is less trouble and just as good. Do not polish, simply rub off dirt with dry cloth. If the emulsion does not flow readily, on account of plates being too cold, you can assist the emulsion to the edges with a glass rod or your finger. If air-bubbles get on the plate, break them with pieces of filtering paper. The greatest cause of failure is too much light in flowing and drying the plates. Also dust is a great enemy. Fog, if not from light, comes from free silver left in the emulsion. An emulsion of this kind can be made all right by putting it again into the brine, leaving for a few hours, and washing as before. The temperature of the brine should be 60°–70° F. (16°–21° C.). Make all your plates in spring for summer use, and in the fall for winter use, as it is much more pleasant. Do not have the flowing room over 80° F. (27° C.)—60°–70° F. is better. Plates that have been exposed to light and not developed, can be soaked in a solution of potash bichromate, washed, dried, and they are as good as before exposure. Be sure and keep plates dry. Dampness is a great enemy to the dry plate. Plates that take a long time to dry are apt to frill. If you wish to make a more intense negative than this formula gives, use same amount of gelatine and less silver; if you want a less intense negative, use more silver and same amount of gelatine.

Always use the same number of grains of ammonium bromide in the brine as you use silver in the gelatine, and reduce or increase the soda carbonate and citric acid in same proportion you reduce or increase the silver. Always use the same amount of gelatine. Any water that is fit to drink is fit to make emulsion. Water that is strong of lime is not good.

For subjects with not much contrast, such as children and fair complexions in light drapery, use 5 per cent. of ammonia iodide in the brine. For dark draperies and dark complexions, use all bromide.

Collodion Processes.—Since the introduction of gelatine processes, collodion has become of less importance, though it possesses some advantages, and has undergone some improvements of late years.

Collodio-citro-chloride Emulsion.—To make this emulsion with ammonia citrate instead of citric acid as the organic body necessary to combine with silver, which is to give vigour to the printed image, is rendered very easy, by a little artifice introduced by Capt. Abney. Ammonia citrate is insoluble in alcohol, and therefore rather difficult to introduce into an emulsion in the ordinary manner; but it can readily be introduced into collodion by the following procedure. Take 10 gr. pyroxyline and cover it with ½ oz. alcohol in which 20 gr. citric acid are dissolved, and then add 1 oz. ether. This forms collodion containing citric acid. In order to get ammonia citrate into the collodion in a very fine state of emulsion, ammonia (gas) dissolved in alcohol is added to the collodion. This is effected by inserting a bent tube in a cork in a test tube, which is a quarter filled with liquor ammonia. Placing this in warm water—in fact, nearly boiling water—the ammonia is given off rapidly, and can be made to pass through alcohol contained in another test tube. The alcohol absorbs the ammonia and takes up a large proportion of gas, as those who use sal-volatile may be aware.

This ammoniacal alcohol is next added to the collodion containing the citric acid, little by little, with shaking and

stirring, and sufficient is added till reddened litmus paper shows a very slight trace of alkalinity. A very fine emulsion of ammonia citrate is thus formed, the grain of which is indistinguishable by the naked eye, and, like other emulsions when first mixed, is orange-coloured when spread upon a glass plate. The emulsion is again rendered slightly acid by the addition of a few drops of a solution of citric acid in ammonia. If an emulsion of silver citrate be required, there are 2 ways of effecting it—one by dissolving (say) 10 gr. silver nitrate in the least possible quantity of water, to which is added 1 dr. alcohol, and gradually dropping it into the collodion containing the citrate. It sometimes happens that this gives a granular emulsion. If, however, the silver nitrate be coarsely powdered, and added to the emulsion, a very fine emulsion of silver citrate is produced by shaking. This may be washed in the usual way, or may be precipitated by pouring in a fine stream into water. Another method of forming the silver citrate is to pour out the emulsion of ammonia citrate into a flat dish, and when well set, to cover it with a solution of silver nitrate. It is then drained from the silver, washed, and dried as usual. When redissolved, the emulsified silver citrate should be excessively fine.

To prepare a collodio-citro-chloride emulsion, 2 plans may be adopted: either to dissolve 20 gr. dry calcium chloride in a small amount of alcohol, and add it to the ammonia citrate emulsion, and then to add 80 gr. silver nitrate to it in the usual way; or to make a collodio-chloride emulsion separately, and then to mix the silver citrate emulsion with it, according to taste.

To make a pure collodio-chloride emulsion, dissolve 20 gr. calcium chloride in ½ oz. alcohol; add to it 5 gr. pyroxyline, and then ½ oz. ether. To 1 oz. plain collodion made similarly, add 60 gr. silver nitrate dissolved in the smallest quantity of water, to which is added 1 dr. warm alcohol. This produces an emulsion of silver nitrate in the collodion. To this the chlorised collodion is added drop by drop with stirring or with shaking in a bottle, and a perfect emulsion of silver chloride should result. This can be poured out to set in a dish as usual, and be washed, dried, and redissolved; or can at once be poured out in a fine stream into a large bulk of water, squeezed, soaked in alcohol twice, wringing out in a cloth all excess of alcohol each time. It can then be redissolved in the 1 oz. ether and 1 oz. alcohol, and should give a good emulsion. The 2 emulsions may then be mixed together as before stated. It is well to dissolve about 5 gr. silver nitrate in water and alcohol, and add to the emulsion in order to increase the rapidity of printing. (*Photo. News.*)

Collodio-chloride Paper.—In a glass beaker dissolve 2 dr. silver nitrate in 1½ dr. distilled water by heat; drop this solution into a bottle containing 14 dr. alcohol. In cold weather it is better to put the bottle in a vessel containing warm water; then add 2 dr. soluble cotton, and, after thorough shaking, 16 dr. ether. On further shaking, a greyish-white collodion will form itself. In another bottle dissolve ¼ dr. lithium chloride in 9 dr. alcohol, together with ¼ dr. tartaric acid. This solution is to be dropped into the argentiferous collodion, which must be shaken all the while. This collodion will keep for any time if preserved in a well-corked black bottle or in a fitting dark cover.

Have a thin piece of wood, same size as the paper that is to be coated, with a knob fastened at the under side; pin the *lichtdruck* paper on it at 3 of the corners, so that the right and lower edge project a little over the wood (this will cause the collodion not to run under the paper), and the left edge of the paper may be turned up a little; but this will not be found necessary after some practice. Now hold the wood with the left hand by the handle, as you would take a glass plate fixed to a pneumatic plate-holder, and pour the collodio-chloride upon the paper just as you would coat a glass plate with collo-

dion. Having returned the surplus of the collodion to the bottle, take the pins away and hang up the paper to dry. The paper will keep for several weeks.

Some prefer to use a pink-coloured *lichtdruck* paper, whose colour will obliterate any trace of yellow that might form by keeping it for a longer period.

The printing must be done in the shade, and weak negatives are better covered by thin, white paper during printing. Toning may be done in an old gold bath that is not too strong. German photographers prefer the following: Make 2 stock solutions—one of ¼ dr. gold chloride in 3 pints water; and one of 5 dr. potassium sulphocyanide, ¾ dr. soda hyposulphite, and ¼ dr. soda carbonate in 3 pints water. Before going to work, mix equal parts of these solutions, but be sure to pour the gold into the sulphocyanide solution, not *vice versâ*.

After having washed the prints in water 3 times changed, put them in the gold bath. If it work too quickly, it will give grey tones. Dilute with water that it may act more strongly; and for weak negatives pass the prints before toning through a 2 per cent. solution of potassium sulphocyanide, the prints becoming of a much richer tone by this. Fix in a 5 per cent. solution of soda hyposulphite (5 minutes will be sufficient), and wash for one hour in water frequently changed.

To make the prints look like enamelled silver prints: clean a sheet of glass, a little larger than the print, and rub it with French chalk; after dusting it off with a brush, lay the print, film side down, on the glasses; put some filtering paper upon it, and go over it with the hand to make the print adhere and to remove air-bubbles. Allow it to dry, and the print will come away with a very high gloss. A part of this it will lose on mounting; but if you mount it at the corners only, as is sometimes done with enamelled prints, it will retain it all. (E. Liesegang.)

Example of Collodion Process. Cleaning the plate.—For polishing the glass plate use

Iodine	1 dr.
Tripoli	3 oz.
Methylated spirit ..	1 pint

Collodionising.—Care is to be taken that the back and edges of the plates are freed from dirt and dust previous to coating, and that the collodion film is allowed to set well before placing in the bath.

Silver Bath.—When compounded of pure silver nitrate and distilled water, as a rule, will work well at once, but sometimes a trace of nitric acid is required so as to make the liquid slowly turn the colour of blue litmus to red.

Silver nitrate	1 oz.
Distilled water	12 oz.
Nitric acid (if required)	about 1 drop.

Developer.—The best and handiest method of compounding the developing solution is to keep a standard solution of iron sulphate.

Iron sulphate	10 oz.
Water	20 oz.
Copper sulphate ..	1 oz.

To make a 20-gr. developer, take

Of the above	2 oz.
Glacial acetic acid ..	6 dr.
Water	18 oz.

Alcohol is required to make the solution flow easily over the plate; about 1 oz. to each pint of developer.

More or less of the standard solution of iron is used as a stronger or weaker developer is required. In the case of under-exposure, a strong developer is very handy to bring out detail and promote harmony; for over-exposure, the negative should be fixed, very thoroughly washed, and intensified afterwards.

In photographing a subject presenting violent contrasts, the use of a strong developer will tend to promote harmony in the negative, and on a subject where the general effect is flat, a weak solution will give a brighter picture.

Intensification.—This is rarely neces-

sary. If, however, it is needed, subjoined are the formulæ:—

Pyrogallic acid	40 gr.
Citric acid	20 gr.
Water	20 oz.

This solution will not keep long: it is to be used with a few drops of a 30-gr. solution of silver nitrate added to each ounce.

Fixing may be accomplished in either potassium cyanide, 20 gr. to each ounce, or in soda hyposulphite, 70 gr. to each ounce; but if the latter be used, more copious washing is required than when cyanide is used.

Varnishing.—Take

Sandarach	¾ lb.
Shellac	2 oz.

Place in a bottle, cover with absolute alcohol, allow to digest for 2 days; pour off the liquid portion into a Winchester, add more absolute alcohol, and again digest for 3–4 days, stirring or shaking occasionally; now mix with that already in the Winchester; add 1 oz. castor oil, shake well, and dilute by filling up the Winchester with methylated spirit; allow to stand, and settle. A Winchester is a stoppered glass bottle holding ½ gal.

Fixing Silver Prints without Hyposulphite.—It is a well-known fact that small quantities of silver chloride are soluble in ammonia, as well as in the chlorides of sodium, ammonium, &c., which, though solvents, are not sufficiently powerful to be used as fixing agents for silver prints. Being engaged in the production of transparencies on glass by the aid of the collodio-chloride process, Dr. Liesegang was struck by the thin layer of chloride and citrate of silver contained in the films, and at once tried the action of the above-named solvents on them. Liquid ammonia cleared the films immediately; a concentrated solution of common salt took about 5 minutes to dissolve the whitish film, the chloride disappearing before the citrate. He next tried to fix untoned collodio-chloride prints upon paper in the same way. Ammonia has the same effect as the usual 5 per cent. solution of hyposulphite, but one cannot think of using it in large quantities in open trays, because of its fumes. Solution (concentrated) of sodium chloride is a little slow in action. He therefore tried a saturated solution of ammonium chloride, in which he left the prints for an hour. It may be that a shorter time is sufficient, or that longer soaking is necessary, but observations led him to think that one hour is a safe time. The prints came out of the bath with the same brownish-yellow colour which also the hyposulphite imparts on them. He washed the prints for one minute under the tap, dried them and exposed them—one half being covered with black paper—to the light. Till now they have had only a few hours of sunshine and 10 days of diffused light; not a trace of difference is observable in the protected and the exposed parts. Of course, this time is not at all sufficient to prove that the fixing is perfect. He next toned a batch of prints in an old toning bath of soda tungstate, very weak in gold, for the usual time of 10 minutes, and kept them for an hour in the ammonium chloride. After drying, they had an unpleasant slate-blue colour, showing that too much gold had been deposited on them. He therefore prepared another batch of prints, which he left only one minute in the gold bath; in the chloride bath they took a vigorous purplish-brown colour, but showed to be somewhat over-exposed, although he had taken care to print less than for hypo fixing. Now, if this way of fixing prints should prove to be safe—which only time can teach us—we shall have the advantage of doing away with hyposulphite, of using less gold for toning, and shortening the time of printing. Comparing the prints with others fixed with hyposulphite, he finds that the finest half-tones are better preserved, and that from under-exposed negatives better results are to be obtained. If the ammonium chloride do not sufficiently fix the prints, you may succeed by adding to it some ammonia. The fixing might be done in the upright vessels in which the prints are hung.

Dr. Liesegang also tried to fix bromogelatine plates of different makers in the saturated salt solution, and he thinks with perfect success. It takes 2–3½ hours to clear the film; addition of liquid ammonia hastens the process. Albumen paper prints lose their chloride in the bath, but the silver albumenate remains and deepens in colour by light. The collodion prints show no sign of alteration in light up to the present time.

Permanent Silver Prints.—Collodio-chloride paper is much made in Germany, the best known makers being Obernether of Munich, and Linde of Lübeck. A quire of this paper costs, including carriage and packing, something like 2*l.* 10*s.*; but as there are now and again streaky sheets in the parcels, that will not produce good prints, the above sum scarcely covers the price really paid. The size of the sheets is 22 by 17 in., which gives 30 C.D.V. pieces, or 10 cabinets. More might be cut from the sheet, but as the edges sometimes fray in the toning and washing, it is better to leave a sufficient margin, so that when trimming the prints a clean and firm edge may be secured. The paper will keep good in a cool place for 2–3 months. The printing should not be so deep as when using albumenised paper, as collodio-chloride prints lose very little of their vigour in passing through the toning and fixing baths. Collodio-chloride prints may be kept for a considerable time before toning—2–3 weeks may elapse—but many prefer toning as soon after printing as possible.

The toning bath is made as follows:—

Stock Solution (*a*).

Ammonium sulphocyanide	1 oz. 2 dr.
Distilled water	60 oz.
Soda hyposulphite	9 gr.

Stock Solution (*b*).

Pure gold	11 gr.
or	
Gold chloride	22 gr.
Distilled water	60 gr.

Fixing Bath.

Soda hyposulphite	1 oz.
Distilled water	12 oz.

The gold used for toning is prepared according to Col. Stuart Wortley's formula; it gives more uniform results when toning collodio-chloride paper than the ordinary commercial samples of gold chloride. The strength of the toning bath is thus more under control, which is absolutely necessary to success with collodio-chloride paper, as anything more than the strength given in the formula produces a flat eaten-out picture without any depth; while, on the other hand, too weak a toning bath gives heavy opaque brown tones. Thus, if the toning goes on too quickly, you lose depth and richness; if very slowly, a brown leathery tone is produced, which is far from satisfactory.

The reason in the first case is that the prints pass so rapidly from brown to black, that before you can well get them removed from the bath, the point where richness lies is often lost. And in the second place, the ammonium sulphocyanide solution in some measure destroys the transparency and purity of the prints when they are left too long in contact with it. Particular care and attention must therefore be given to the toning bath, so as to have it neither more nor less than the strength stated, as collodio-chloride photographs are much easier stained in toning than prints upon albumenised paper; and when unequal toning does take place, it is more visible in the former than in the latter.

In making up a bath, equal quantities of (*a*) and (*b*) are mixed, plenty of chalk being added, letting the whole stand for 3–5 hours before use. With some samples of this paper, the bath can be used at once; but with other sheets, this is not the case, a deposit of gold taking place over the whole prints, and destroying the purity of the whites. It is better, therefore, to err on the safe side by making up the bath a considerable time before it is required, and thus

be assured of having a uniformity in one's photographs. When you have many prints to tone, use 2 flat dishes capable of holding, say, 1 doz. prints each. Filter the solution into these dishes to the depth of ¼ in.; were the liquid deeper, the prints would not keep flat. Wash in 3 changes of water; and as the prints generally curl up into tubes, open each of them separately in the water, so as to get the surface uniformly washed. If this is not done, and done in each separate dish of clean water, uneven toning will be sure to take place.

When the prints have been properly washed with a quick but gentle movement, open up each picture, and lay it flat in the bath face downward; and when the dish is full, begin at the first and turn it over, brushing the face with a camel-hair brush, and continue the process until the whole have been so treated, afterwards turning them back again into their former position, and so on without cessation, until the prints are ready to leave the bath. When stains occur in the course of toning, lift the print out of the solution, dip the brush in alcohol, and rub the spot slightly. Then immerse the print again, when it will be found that the stain has disappeared, and the print has been saved.

When fixing the prints, the same care is required in laying them separately in the fixing solution, turning them over, and keeping them in motion until they are fixed, which is completed, when the fixing bath is new, in 3–5 minutes. When removed from the bath, the prints are immersed for a few minutes in 3 or 4 changes of water, and put under the tap for 1–2 hours. The water is then shut off, and they are left all night, and throughout the next day until the afternoon; the water is changed now and again. The prints are then trimmed and mounted. The system in use amongst the many of the profession, of cutting the prints to the exact size wanted before toning them, cannot be readily adopted with collodio-chloride pictures. In their case the paper should always be a little larger than is necessary, allowing not less than ⅛ in. to be cut off all round after the prints have been toned, fixed, and washed. The reason for this is that the edges of the prints are very curly, and the film becomes frayed in the course of washing; by cutting away this frayed curly part, they are more easily and neatly mounted. As it is impossible to lay these prints upon blotting-paper and dry them in a flat state without cracking the surface, another method has to be put in practice for the purpose of trimming them. Use a piece of thin plate glass, cut to the exact size of what the carte-de-visite print should be, the edges being ground and the corners slightly rounded, so as not to scratch the picture. If the prints are more than ordinarily curly, open them *underneath* the water, and lay the sheet of glass upon the face, and then lift both of them out of the water at once, the moisture between them enabling you to move and adjust the glass over the print with the greatest ease. Then, with a pair of long-bladed scissors, cut along the 4 edges of the glass, and thus secure a straight clean-cut print, without damaging the surface of the photograph.

The medium for mounting is starch, carefully boiled, as thick as possible. It is, while still warm, poured into the centre of a muslin cloth, the corners of which are drawn together and held firmly with the left hand, while the right hand presses the bag and causes the pure starch to exude through the interstices of the cloth — the result being a paste perfectly free from gritty matter, and of the right consistence for mounting.

A sheet of thick plate glass is covered with a damp cloth, and the prints are lifted from the dish and laid upon it in a wet condition, the water on the face of the prints and the damp cloth preventing them from curling. They are then pressed quite flat with another cloth, and dried before they are starched.

After the prints are mounted, dried, and spotted out, roll them upon a hot steel plate; they are then put up in

dozens into paper and laid upon the machine plate, and when warm are rubbed over with "Salomon paste," which gives them a richness and transparency they would not otherwise possess.

If desired, these photographs may very easily be covered with "Mawson's print varnish" or "enamel collodion" by coating them with a camel-hair brush of the same breadth as the card. Some think they are more beautiful and artistic when simply finished with wax paste. At first, the manufacturers of collodio-chloride papers were not so careful as they are now regarding the basis on which the collodion film rests; nay, there is reason to believe that sheets of albumenised paper were then used as a support for the emulsion. In such a case, the prints made from those sheets are liable to fade.

Tourists' preservative Dry-plate Process.—In the following note, the author's aim has been principally directed to prepare films by the use of a collodion and bath, combining, with long keeping properties, adaptability to the ordinary wet process worked with iron development. The great susceptibility of highly sensitive films to injury from weak luminous radiations during preparation, exposure, and development, render reliable plates of moderate sensibility a perfect desideratum. Such, when worked with others of high sensibility, if easily prepared and developed away from a specially constructed laboratory, constitute essential requisites for the amateur landscape photographer.

Although any collodion of recognised standard excellence for iron development is perfectly suitable, yet in the manufacture of pyroxyline, the 3 to 1 proportion of sulphuric to nitric acid, originally recommended in the patent for explosive cotton, and subsequently ably advocated for the soluble varieties, is not found to be the best. The employment of a larger quantity of nitric acid to the sulphuric, yields a better result for the soluble kinds. The following formula is based, therefore, on this consideration:—

Sulphuric acid, sp. gr. 1·84	6 fl. oz.
Nitric „ „ 1·42	3 „
Water	5¾ fl. dr.
Cotton	150 gr.

Temperature, 155° F., descending to 145° F. Time of immersion, 10 minutes.

The double temperature given signifies that, at the time of the introduction of the cotton, the acids should be at 155° F., and the allowable decline must not exceed 10°. Mix 6 fl. dr. of a plain collodion, made by dissolving 5–6 gr. of the above pyroxyline in a mixture of 4 fl. dr. methylated ether, sp. gr. ·720, and 2 fl. dr. pure alcohol, sp. gr. ·820, with a bromo-iodising solution made as follows:—

Sodium iodide	6 gr.
Cadmium bromide ..	4 gr.
Iodine	½ gr.
Guaiacum	¼ gr.
Alcohol, sp. gr. ·820 ..	2 fl. dr.

Before coating the plate, apply a substratum consisting of 1 oz. liquid albumen and 30 minims liquor ammoniæ, sp. gr. ·959, dissolved in 1 pint water. After the plate is coated, excited in an ordinary argentic nitric bath, and removed therefrom, it is to be freely washed in ordinary water kept in motion, and then treated with the following preservative, poured on and off the film twice or thrice from different parts.

Preservative.

Albumen	1 fl. oz.
Glucose solution (raisins 1 part, water 5 parts)	2 „
Water	3 „
Liquor ammoniæ, sp. gr. ·959	15 m.
Ammonium chloride ..	3 gr.
Ammonium bromide ..	½ gr.

The film is again to be freely washed with ordinary filtered water, and covered with a 3-gr. solution of gallic acid, and evenly dried. The back of the glass, as a matter of precaution against very trying conditions, rather than as an ordinary necessity, should be covered with a non-actinic colour. Burnt sienna ground in water and mixed with a little

gum mucilage, constitutes a good medium for the purpose.

At any convenient interval after exposure, the film is washed, and developed with a suitable quantity of solution made in the following proportions:—

Water	4 fl. dr.
Pyrogallic acid (64 gr. dissolved in 1 fl. oz. alcohol, ·805)	15 m.
Potassium bromide (16 gr. in 1 oz. water) ..	15 m.
Sodium carbonate (64 gr. in 1 oz. water) ..	15 m.

Only 5 m. of the potassium bromide should be added in the first instance, and the remainder upon the earliest indication of an image. As soon as the general details of the picture become faintly visible by reflected light, the alkaline developer should be removed, and a 3-gr. solution of citric acid applied. The intensification may then be effected with pyrogallic acid, citric acid, and argentic nitrate, and the unreduced salts dissolved away with sodium hyposulphite as usual. (T. Sebastian Davis.)

Transparencies.—When the season for outdoor work closes, amateurs begin to look about for means of employment during the dark evenings. One of the most pleasing occupations is the production of transparencies for the lantern, by artificial light, with Beachy's dry collodion plates.

It may be interesting to some to know the formula by which the emulsion is made, as the making of it is by no means a difficult operation. The formula is as follows:—In 8 oz. absolute alcohol dissolve 5 dr. anhydrous cadmium bromide. The solution will be milky. Let it stand at least 24 hours, or until perfectly clear; it will deposit a white powder. Decant carefully into an 8-oz. bottle, and add to it 1 dr. strong hydrochloric acid. Label this "bromide solution"; and it is as well to add on the label the constituents, which will be found to be nearly—

Alcohol	1 oz.
Cadmium bromide ..	32 gr.
Hydrochloric acid ..	8 drops

This solution will keep for ever, and will be sufficient to last 2–3 years; with this at hand, you will be able in 2 days to prepare a batch of plates at any time. In doing so, proceed thus:—Make up your mind how many plates you mean to make, and take of the above accordingly. For 2 doz. ½-plates or 4 doz. 3¼ by 3¼, dissolve by heat, over, but not too near, a spirit lamp, and by yellow light, 40 gr. silver nitrate in 1 oz. alcohol ·820. Whilst this is dissolving in a little Florence flask on a retort stand at a safe distance from the lamp—which it will do in about 5 minutes—take of the bromised solution ½ oz., of absolute ether 1 oz., of guncotton, 10 gr.; put these in a clean bottle, shake once or twice, and the guncotton, if good, will entirely dissolve. As soon as the silver is all dissolved, and whilst quite hot, pour out the above bromised collodion into a clean 4-oz. measure, having ready in it a clean slip of glass. Pour into it the hot solution of silver in a continuous stream, stirring rapidly all the while with a glass rod. The result will be a perfectly smooth emulsion without lumps or deposit, containing, with sufficient exactitude for all practical purposes, 8 gr. bromide, 16 gr. silver nitrate, and 2 drops hydrochloric acid per oz. Put this in your stock solution bottle, and keep it in a dark place for 24 hours. When first put in, it will be milky; when taken out, it will be creamy; and it will be well to shake it once or twice in the 24 hours.

At the end of this time, you can make your 2 doz. plates in about 1 hour. Proceed as follows:—Have 2 porcelain dishes large enough to hold 4 or 6 of your plates; into one put sufficient clean water to nearly fill it, into the other put 30 oz. of clear, flat, *not acid*, bitter beer, in which you have dissolved 30 gr. pyrogallic acid. Pour this through a filter into the dish, and avoid bubbles. If allowed to stand an hour, any beer will be flat enough; if the beer be at all brisk, it will be difficult to avoid small bubbles on the plate. At all events, let your preservative stand while you filter your emulsion. This must be done

through perfectly clean cotton-wool into a perfectly clean collodion bottle; give the emulsion a good shaking, and when all bubbles have subsided, pour it into the funnel, and it will all go through in 5 minutes. The filtered emulsion will be found to be a soft smooth creamy fluid, flowing easily and equally over the plates. Coat with it 6 plates in succession, and place each, as you coat it, into the water. By the time the sixth is in, the first will be ready to come out. Take it out, see that all greasiness is gone, and place it in the preservative, going on till all the plates are so treated.

A very handy way of drying is to have a flat tin box of the usual hot plate description, which fill with hot water, then screw on the cap; on this flat tin box place the plates to dry, which they will do rapidly; when dry, store away in your plate box, and you will have a supply of really excellent dry collodion plates.

Just a word as to the preparation of the glasses before coating. It is very generally considered that it is better the glasses receive either a substratum of albumen, or very weak gelatine. After your glasses are well cleaned, place them in, and rub them with a weak solution of hydrochloric acid of the strength of 2 oz. acid to 18 oz. water.

Prepare a solution of gelatine, 1 gr. to the oz. of water, rinse the plate after removal from the acid mixtures, and coat twice with the above gelatine substratum; the first coating is to remove the surplus water, and should be rejected. Rear the plates up to drain, and dry in a plate rack, or against a wall, and be careful to prevent any dust adhering to the surface while wet.

If we take a negative, and in contact with it place a sheet of sensitised paper, we obtain a positive picture. Substitute for the paper a sensitive glass plate, and we obtain also a positive picture, but, unlike the paper print, the collodion or other plate will require to be developed to bring the image into view. Now this is what is termed making a transparency by contact. It often happens, however, that a lantern slide $3\frac{1}{4}$ by $3\frac{1}{4}$ has to embrace the whole of a picture contained in a much larger negative, so that recourse must be had to the camera, and the picture reduced with the aid of a short focus lens to within the lantern size; this is what is called making a transparency by reduction in the camera. Both cases are the same, however, so far as the process being simply one of printing.

Those who have never made a transparency will have doubtless printed silver prints from their negatives, and when printing, how often do you find that to secure the best results you require to have recourse to some little dodge.

Now, let us bear this in mind when using such a negative for the printing of a transparency. Although we cannot, when using a sensitive plate, employ the same means of dodging as in the case of a silver print, still we are not left without a means of obtaining the same results in a different way, and a deal more depends on the manipulative skill of the operator than in the adoption of any particular make of plate, or formula; and not only does this manipulative skill show itself in the exposure, development, &c., but likewise comes into play in a marked manner even in the preparation of the negative for transparency printing.

A negative whose size bears a proportion similar to $3\frac{1}{4}$ by $3\frac{1}{4}$ will lend itself more easily to reduction; thus whole-plate or half-plate negatives are easy of manipulation in this respect, and require but little doing up. But as other sizes have at times to be copied into a disc $3\frac{1}{4}$ by $3\frac{1}{4}$, recourse must be had to a sort of squaring of the negative.

In a good lantern transparency, it is, of all things, indispensable that the high lights be represented by pure glass, absolutely clean in the sense of its being free from any fog or deposit, to even the slightest degree; it is also necessary that it be free from everything of heaviness or smudginess in the details. To obtain these results, you may have re-

course to the strengthening of the high lights of the negatives, and this is done with a camel-hair brush and india ink, working on the glass side.

Block out the skies, and so strengthen the other parts of the negatives, that you can rely on a full exposure without fear of heaviness or smudginess. This blocking out is easily done.

The apparatus may be a whole-plate camera, very strongly made, and with a draw of 23 in. when fully extended. Use a Ross rapid symmetrical lens on 5 in. focus, a broken-down printing frame with the springs taken off, and a sheet of ground glass. This is all that is required, though it is generally believed that a special camera is required for this work, such as to exclude all light between the negative and the lens. There is nothing to hinder the use of ordinary cameras, provided the draw is long enough, and the lens a short focus one.

Take the negative and place it in the printing frame, holding it in its place with a couple of tacks, film side next the lens, just as in printing; then stand the printing frame on its edge on the flat board, and place the ground glass in front of it, between the light and the negative. The ground glass can conveniently be placed in another printing frame, and both placed up against each other. Then bring the camera into play, and so adjust the draw and distance from the negative till you get the picture within the disc on the ground glass. The best way is to gum a transparency mask on the inside of the ground glass; this permits of the picture being more easily brought within the required register. This done, focus sharply, cap the lens, and then proceed to make the exposure.

Regarding exposure. Bear in mind again that it is merely a printing process we are following up, as you will all know that in printing no 2 negatives are alike in the time they require. So in this case, no 2 negatives are the same in their required exposure. Still, with the plates used, so wide is their range for exposure, that but few failures will be made on this score, provided we are on the safe side, and expose fully.

Although these plates are not nearly so fast as gelatine plates, they give good results in about 1½ minute by burning magnesium ribbon. Never allow the ribbon, when burning, to remain in one position, but keep it moving from side to side, and up and down, in front of the ground glass while making the exposure; and if there be any dense place in the negative which, as in printing, would have required printing specially up, allow the light to act more strongly on that part; the result, as a rule, will be an evenly and well exposed plate.

To coil up the ribbon before setting it alight, take an ordinary lead pencil and wind the ribbon round and round, thus making a sort of spiral spring; this done, gently pull the coils asunder, then grasp the end of the ribbon with a pair of pincers, light the other end, and make the exposure.

For development, use a canary light, with which you can easily see to read a newspaper. The canary medium is inserted between 2 sheets of glass 7¼ in. by 4½ in., the 2 glasses are then fastened on to the tin with gummed paper, a few holes are bored in the back for air, a funnel is let in, and the thing is complete.

The formula for development is as follows:—

Pyro	96 gr.
Methylated spirits ..	1 oz.
Potash bromide	12 gr.
Water	1 oz.
Ammonia carbonate ..	60 gr.
Water	1 oz.

Mix 30 drops pyro with 30–60 drops bromide, then add 2 dr. ammonia solution and 2 dr. water.

A thin negative requires a slow development, and so gains contrast; while hard negatives are best over-exposed and quickly developed.

The plate is first placed in water or rinsed under a gentle stream from the tap till all greasiness has disappeared, it is then placed in a flat dish, and the developer is applied. Should it be

found that some parts of the picture are denser printed than they should be, by the ribbon acting more strongly on some particular part—this is often the case if the negative has been thinner in some parts than others through uneven coating of the plate—the picture need not be discarded as a failure.

Fix the plate in hypo—the fixing takes place very quickly—then examine the picture for the faults above described; if they are found, wash the plate under the tap gently, and bring into operation a camel-hair brush and a weak solution of potassium cyanide. Apply the brush to the over-printed parts, taking care not to work on the places that are not too dense. Do not be afraid to use plenty of washing while this is being done; let it be, as it were, a touch of the brush and then a dash of water, and you will soon reduce the over-printed parts. It only requires a little care in applying the brush.

After this wash well, and should it be deemed necessary to give a black tone, use a weak solution of platinum bichloride and gold chloride, or a very weak solution of iridium, in equal quantities, allowing the picture to lie in the solution till the colour has changed right through to the back of the glass. Should a warm pinkish tone be desired, tone with weak solutions of potassium ferricyanide, uranium nitrate, and gold chloride in about equal quantities.

After toning, wash well and dry: they dry quickly. Varnish with Soehnee crystal varnish, then mount with covering glasses, and mark. Bind round the edges with paper and very stiff gum, and the picture is complete.

The making of a really good transparency is by no means an easy or pleasant task with a wet collodion plate, but with these dry plates an amateur can, with a little practice, produce comfortably, slides quite equal to those procurable from professional makers. (T. N. Armstrong.)

Ground.—Mix the whites of 2 eggs, well beaten, 6 pints water, and 1 dr. liquid ammonia.

Collodion formula.—Mix 6 oz. sulphuric acid, 4 oz. nitric acid at 1·450 sp. gr., and 2 oz. water. The temperature will rise to about 170° F. (77° C.); when it has cooled down to about 100° F. (38° C.), immerse perfectly dry cotton-wool (best carded and of long fibre), pull it in under the acid with a piece of glass rod, and let each piece be well saturated before adding another. Cover the vessel, and leave it for 12–20 hours in a situation where any fumes generated may escape into the outer air. Next lift the cotton out, and plunge it quickly into a large quantity of water, separating the tufts with pieces of glass; wash in changes of water till no acid is left. Wring the cotton in a coarse towel as dry as possible, and then pull out the tufts, and place them in the air to dry. Collodion made with this cotton will be very soluble and leave no sediment; 5–6 gr. will dissolve in 1 oz. mixed ether and alcohol, and still the collodion will be very fluid.

To prepare one pint of collodion with above:—

(*a*)	Alcohol	10 oz.
	Sulphuric ether	5 oz.
	Cotton as above	100 gr.
	To Iodise:—	
(*b*)	Alcohol	5 oz.
	Ammonium iodide ..	60 gr.
	Cadmium iodide	30 gr.
	Cadmium bromide ..	20 gr.

Shake till dissolved, and then pour into (*a*).

Another plan, better for small quantities:—

Dissolve the iodides, as above, in 10 oz. alcohol, then put in 100 gr. cotton, and shake well. Lastly, add 10 oz. ether, and shake till cotton is dissolved. This collodion will be ready for use in a few hours, but will improve with age.

Saturated Iron Solution.—Fill a Winchester quart ¾ full of crystals of iron protosulphate, and add 1 oz. copper or zinc sulphate. Fill up with water, shake well repeatedly. Carefully cork the bottle, and lay it gently on its side until next morning. Again shake, and the solution will be ready for use. Al-

ways keep full up to stopper with water. Always have the bottle half full of crystals. The use of the copper or zinc sulphate is to prevent the formation of sediment of iron persulphate.

Developer with above Solution.

Iron protosulphate (sat. sol. as above)	2 fl. oz.
Acetic acid	1 oz.
Water	20 oz.

Iron Developer for Negatives.

Iron protosulphate (sat. sol.)	2 fl. oz.
Copper sulphate	1 dr.
Baryta nitrate	1 oz.
Glacial acetic acid ..	½ oz.
Water	20 oz.

When dissolved, filter out white deposit, and keep closely corked.

Henderson's Iron Developer.

Iron protosulphate	20 gr.
Glacial acetic acid	20 m.
Alum	40 gr.
Water	1 oz.

Nitrate of Iron Developer for Ferrotypes.

Iron protosulphate	1½ oz.
Baryta nitrate	1½ oz.
Nitric acid	20 drops
Water	20 oz.

When dissolved, filter from dense white deposit of baryta sulphate, and keep in closely corked bottle. N.B.—It rapidly spoils when exposed to the air. Pictures by this process are of a very brilliant pearly white.

Collodio-chloride Printing Process.

16-gr. alcoholic solution of silver nitrate, 1 oz. (by pounding silver salt with methylated spirit in a mortar).

Sulphuric ether	1 oz.
Pyroxyline	12–14 gr.

When dissolved, add 1½ dr. 16-gr. alcoholic sol. calcium chloride; shake well, and keep carefully from light. A sizing of arrowroot should be applied to paper before pouring on collodio-chloride.

Intensifying Solution for Wet-plate Negatives.

(*a*) Iron protosulphate (sat. sol.)	2 oz.
Acetic acid	1 oz.
Citric acid	½ oz.
Water	20 oz.

Silver solution, as much as is necessary to make negative dense.

(*b*) Pyrogallic acid	10 gr.
Citric acid	25 gr.
Distilled water	2 oz.

Add a few drops of silver nitrate solution, 10 gr. per oz.

Developer for very delicate Transparencies.

Pyrogallic acid	3 gr.
Citric acid	1 gr.
Water	1 oz.

This development is slow, but the deposit is very fine. Tone with gold, 1 gr. to 10 oz. water.

Durable Sensitised Paper.

Float the albumenised paper on a 10 per cent. solution of silver nitrate for 4 minutes, draw it over the glass rod to drain, and then float the back of the sheet for a like period upon a bath composed of

Potash citrate	1 part
Water	30 parts

Final wash in rain water. Gold sulphocyanide toning suits best with this formula.

Werge's Gold Toning Bath.

(*a*) Borax	1 oz.

dissolved in hot water; when all dissolved, dilute to 80 oz. Keep this in Winchester quart as stock solution. To tone, take for each gr. of gold 8 oz. of above solution; mix. The bath is ready for work at once.

(*b*) Gold chloride	1 gr.
Soda acetate	20 gr.
Water	8 oz.

Lime Toning Bath.

(*a*) Gold chloride	.. ..	1 gr.
Whiting	.. .. ..	30 gr.

Pour on 8 oz. boiling water, and stir. Now add 1 drop saturated lime chloride solution. When cool, bath is ready for use.

(*b*) Gold chloride	.. ..	1 gr.
Soda bicarbonate	.. ..	3 gr.
Water	.. ..	8 oz.

To be used at once.

(*c*) Gold chloride	.. ..	1 gr.
Soda phosphate	.. ..	30 gr.
Water	.. ..	8 oz.

Collodion Enlargements—Croughton's Method.

Soak polished flatted crown glass in soda for some time. After well washing, immerse in weak sulphuric or hydrochloric acid, say 1 oz. to 1 qt. of water. Rinse well, and dry with clean cloth. Polish with wash-leather. Well wax polished side of glass with waxing solution made as follows :—

Yellow beeswax	.. .. ..	1 dr.
Benzole	.. ..	3 oz.

Use weak acid bath of silver nitrate. Develop with iron as follows :—

Iron protosulphate	.. ..	6 dr.
Glacial acetic acid	.. ..	2 oz.
Citric acid	.. .. ..	60–80 gr.
Sugar-candy	.. .. ..	30 gr.
Water	.. ..	20 oz.

Fix in hyposulphite 4 oz. to 1 pint water. Well wash. For transfer, use Autotype double transfer paper. Soak 20 minutes in cold water. Now place paper in hot water till surface feels slimy. Place face down on the wet collodion surface, and gently squeegee. When dry, the picture will come from glass.

Printing on Fabric.

Remove all dressing from fabric by boiling in water containing a little potash, dry, and albumenise with 2 dr. ammonium chloride, 62 dr. water, and the white of 2 eggs, all being well beaten together. A 70-gr. silver bath is used, and the remaining operations are as for paper.

Winter's Canvas Enlargements.

Salting solution :—

Potassium bromide	..	3 parts
Potassium iodide	.. ..	1 part
Cadmium bromide	..	1 part
Water	.. ..	240 parts

German canvas is said to be better than English. This is immersed in the above, and when saturated, is drawn over glass rod and hung up to dry; it is then placed in a sensitising bath made as follows :—

Silver nitrate	.. ..	4 parts
Citric acid	.. .. ..	1 part
Water	.. ..	140 parts

drawn over rod as before; when dry, is ready for exposure, which should be continued until outline of image is visible.

Developer.

Pyrogallic acid	.. ..	10 parts
Citric acid	.. .. ..	45 „
Water	.. ..	410 „

This should be used at a temperature of 86°-104° F. (30°-40° C.), the canvas again immersed, and rocked to and fro until sufficiently out; washed freely, and fixed in the usual hypo solution; canvas being more permeable than paper, less after-washing is necessary.

Albumen Processes. *Albumenising Paper.*—The first thing is to decide how much albumen has to be prepared to coat the quantity of paper required. As a guide, it may be mentioned that a ream of paper will consume $1\frac{1}{2}$–2 gal. albumen; and as one egg yields $\frac{3}{4}$–1 oz. albumen, according to its size, it is easy to arrive at the number that will be required to coat a given quantity of paper, bearing in mind that more than is actually consumed by the paper must be prepared—sufficient to well cover the bottom of the dish when the last sheet is floated. Thus, a couple of quires of paper (a convenient quantity for an amateur to prepare at a time) will take

something like 1 qt. of albumen; this, on an average, will be obtained from about 50 eggs. If the paper be coated in the whole sheet, of course considerably more than this will be necessary; but for the nonce we shall assume that the paper will be prepared in quarter sheets, as that will be the most convenient size for the novice to commence with.

Fresh white of eggs can now be purchased in any quantity, the egg merchants finding it to their advantage to break the eggs and sell the albumen and yolks separately, as there is a large demand for both, but for different purposes—the former for albumenising paper for photographic purposes, and the latter in the preparation of kid leather for the manufacture of gloves. Therefore, when the albumen can be conveniently purchased separately it will be found more economical. However, we shall assume that this cannot be done, and therefore the eggs must be broken by the operator himself. Here some little dexterity is required in order to avoid the yolk getting mixed with the whites. The best plan is to break the egg by giving it a smart tap on the edge of the cup, and then drain the albumen into it, retaining the yolk in the shell. By draining the white from each egg first into a cup, the yolk, if it be accidentally broken, does not get mixed with the bulk of the albumen. The yolks can, of course, be transferred to the culinary department.

It is generally recommended, in breaking the eggs, to separate the germ from the albumen, but this is never done in actual practice. With regard to the kind of eggs to be used, good ordinary French eggs will answer quite well, and they will be found practically as good as the more expensive "new laid." The requisite quantity of albumen being obtained, it is well stirred up, and to each quart, 300 gr. ammonium chloride, dissolved in the smallest possible quantity of water, is added. The whole must now be converted into a perfect froth. Unless this part of the operation be very perfectly performed, it will be quite impossible to ensure a perfect coating. Professional albumenisers usually employ an American churn for this purpose; but, on a small scale, the domestic egg whisk borrowed from the kitchen will answer quite as well. The whisking must be continued until the vessel containing the albumen can be inverted for a minute or two without any of the albumen draining out. The vessel is then placed away in the cool place for 3–4 days, according to the temperature, to allow the albumen to subside. By this time, it will have become very limpid. If the albumen be kept in a cool place, and the eggs be tolerably fresh when broken, it will keep the above length of time without fear of decomposition. It could be used after a day's keeping, but it would be next to impossible to obtain a coating perfectly free from streakiness.

Some keep the albumen for a much longer period than that named—or until it has become quite putrid—before use, as then it is more easy to manipulate, and produces a finer gloss. We have been given to understand that dried blood albumen is sometimes added to thicken that obtained from the eggs, so as to obtain a still higher surface. The proportion of chloride recommended above will give 7½ gr. to the oz. of albumen, and will, therefore, be suitable for a 60-gr. sensitising bath.

Leaving the subject of the albumen for a few minutes, it will be well to direct attention to the paper itself. It is tolerably well known that the 2 sides of a sheet of paper are different, one being very smooth, while the other possesses a certain amount of roughness, due to the web upon which it was dried in its manufacture. It is the smoother side which is to be albumenised. As the reams are received from the mill, the smoother side is always packed in the same direction; but when the ream is broken, and the paper sold in small quantities, it frequently gets mixed. Therefore it is necessary to examine each sheet separately, and in cutting it up—supposing it is to be prepared in less than whole sheet—to take the precaution

that the smoother surface is arranged all one way, so that no mistake need be made in floating the wrong side on the albumen.

The albumen having stood the requisite time, it is now carefully strained; a fine cambric handkerchief will form a good medium for the purpose. After straining, the most careful albumenisers filter the albumen through a sponge; but this is scarcely necessary if the cambric be close in texture, and the albumen has been carefully decanted without disturbing the sediment. It is now poured into a dish of a suitable size, avoiding the formation of air-bubbles as much as possible. After standing for a short time, to allow any minute ones that may be accidentally formed to come to the top, the albumen is carefully skimmed by drawing a piece of blotting-paper along its surface. It is now ready to receive the paper.

In floating the paper, some little dexterity is required to avoid bubbles, and many operators have different plans of placing it upon the albumen. Some bend the paper in a curve and apply the middle first, and then gently lower the 2 ends. Others, holding it by opposite corners (diagonally), bend it, and apply first one of the free corners, gently lowering it to the other, and finally lower the 2 corners by which it is held. Many apply the paper in this way, and it is the plan we prefer: Holding the sheet by its 2 ends, they place one on the surface of the albumen at one end of the dish, and gently lower the remainder. By this method any air-bubbles, should they be accidentally formed, will be driven toward the end of the sheet, where they can easily be forced out by gently tapping the back of the paper with the tips of the fingers; whereas if any be formed when the middle of the sheet is applied first they are not so easily noticed, or expelled when they are.

When the paper is first applied—particularly if it be very dry—it will probably curl up and leave the albumen at the edges, but it will speedily flatten out again. It must not, however, be removed until it lies uniformly flat; otherwise the coating will prove unequal in thickness when dry. In practice it is advantageous to employ 2 dishes, and it will then be found that by the time the second sheet is floated the first one will have become flat and ready for removal, and thus time will be considerably economised. If the paper be floated for too long a time the albumen will sink deeply into it, and thus to some extent prevent a high gloss being obtained. (*Brit. Journ. Photo.*)

Floating Albumenised Paper on the Silver Bath.—The silver nitrate which is taken up from the sensitising bath when albumenised paper is sensitised, serves 3 distinct purposes. In the first place, double decomposition takes place between it and the soluble chloride in the albumen, so as to form silver chloride in the film of albumen, and a soluble nitrate, which remains in the solution. The silver chloride is, as all know, the principal sensitive substance in the paper. There is, besides this, an organic compound formed by the decomposition of the albumen itself by silver nitrate. The formation of this second compound is a second function of the silver nitrate. The third is that of acting as a "sensitiser." The silver chloride darkens only slowly if there be no silver nitrate present, nor any other substance which will take the place of the silver nitrate to absorb the chlorine given off when the silver chloride is reduced by light.

To estimate the quantity of silver nitrate necessary to convert the soluble chloride in the albumen into silver chloride is easy enough, if one knows how the albumen was salted, and how much each sheet takes up.

According to a formula given in Hardwich, each sheet of paper of the usual size, 17 × 22 in., takes up with the albumen about 7 gr. ammonium chloride. To convert 7 gr. ammonium chloride into silver chloride requires, as nearly as possible, 22¼ gr. silver nitrate.

We know of no reliable data for the amount of silver nitrate used to produce the organic compound referred to, but from experiments we have made with albumenised paper, estimating the

amount of silver nitrate necessary to convert the soluble chloride, noticing the quantity of silver nitrate taken from the bath, and the quantity afterward recovered by thoroughly washing the paper—without exposing it to light—we conclude that the quantity is very small, probably not more than 2–3 gr. to the sheet.

The quantity of free silver nitrate remaining in the paper after sensitising may very easily be ascertained. It is only necessary, after sensitising a sheet, to wash the free silver nitrate out of it with distilled water, and to estimate the quantity of it in the usual volumetric manner. From estimations made by ourselves on the lines indicated, we may say that the amount of silver nitrate remaining in the paper in excess after sensitising is fairly represented by the actual diminution in bulk of the printing bath. We mean that, for example, if 3 sheets of paper take up 1 oz. of a 60-gr. bath, there will remain in each sheet of paper 20 gr. free silver nitrate, the further nitrate required to produce the silver chloride and organic compound serving only to weaken the remaining solution.

Taking Hardwich once more as an authority, we find that an average quantity of bath to be used up by a quire of paper is 8 oz., that is to say, each sheet of paper removes $\frac{1}{3}$ oz. of fluid from the bath.

Our own experience would incline us to put this figure a little higher in ordinary circumstances; the quantity absorbed varies greatly with the paper. Thick paper naturally absorbs much more of the bath than thin paper does. Making an average, we should say that a quire of paper reduces the bath by about 9–10 oz. Taking this quantity as correct, and supposing the bath to be a 60-gr. one, we find that almost precisely the same quantity of silver nitrate is taken up merely to form a chlorine absorber as is used to form the important sensitive salt. This appears to be somewhat extravagant, and has been felt to be so for a long time. More than 20 years have elapsed since it was pointed out that the silver bath might be greatly reduced in strength if part of the silver nitrate were replaced by sodium nitrate, which would serve as well as the silver nitrate to coagulate the albumen of the film. Doubtless economy resulted; but somehow, so far as we know, the method was never very popular.

There are other methods of economising, however, which ought to be taken notice of. It is well known to practical printers that it is a great advantage to have the albumenised paper damp before it is floated. The edges do not curl away from the bath in the aggravating manner that they do when the paper is dry, and air-bubbles are less likely to be formed. These advantages are fairly well known, but we do not think that it is known how great an absolute economy there is in using the paper as damp as is practical, this economy arising from the mere fact that much less of the silver nitrate bath is absorbed by paper when it is damp than when it is dry. We were astonished to find how great an economy really results from the use of damp paper.

Some time ago we were working with a very highly albumenised and very thick paper, which reduced the bulk of the bath very greatly. We noticed that the amount of bath absorbed varied with the dampness of the paper, and determined to find out the extent of the variation.

We first used the paper very dry—as dry as it was practicable to handle it. We discovered that each sheet reduced the bath by more than $\frac{1}{2}$ fl. oz.

We next made the paper as damp as was possible without danger of softening the albumen. We now found that each sheet absorbed barely $\frac{1}{3}$ oz. of bath. The prints given by the paper sensitised when damp were of quite as good quality as those got on that sensitised dry. The bath which we were using was a 60-gr. one, and we found the damping of the paper to result in the saving of quite 12 gr. silver nitrate per sheet, or not far short of 380 gr. per quire.

Concerning the manner of damping the paper, a few words may be said.

It is a common plan to keep albumenised paper in a damp cellar. In fact, this course is often recommended by dealers in albumenised paper. Many have not a cellar damp enough at their command. Moreover, it is objectionable to store albumenised paper in a damp place. It should merely be placed in such, if such be available, a few days before it is to be used, which often involves some trouble.

Abney recommends that the steam from a boiling kettle be allowed to play on the paper a moment or two before it is sensitised.

The following is the plan we have ourselves adopted: On the shelf of a cupboard which has but one, the albumenised paper is laid flat, the albumen sides of the sheets upward; ½ hour before commencing to sensitise, a vessel of boiling water is placed on the bottom of the cupboard. There is room for the steam to pass up between the front edge of the shelf and the door of the cupboard. The water is replenished from time to time during working. The paper is thus kept very damp, and apart from the saving in silver effected, the comfort in working is greatly increased. (*Photo. News.*)

Silver Printing on Albumenised Paper. The Silver Printing Bath. — Without doubt the best results are obtained from the use of a plain neutral solution, kept as near as possible to its full strength, varying from 45 to 60 gr. of silver nitrate per oz. of water, kept as near neutral as possible by means of soda carbonate, and floating 3–5 minutes.

To prepare a sensitive paper that keeps white for a week or so, nothing has been published that works so well as Mr. Blanchard's formula, as follows:—Prepare the silver solution, 60 gr. to the oz., and be careful not to allow it to sink lower than 50 gr. to the oz.; for each oz. of nitrate used, add 10 drops of a saturated solution of citric acid; now add nitric acid drop by drop, until the slight precipitate of silver citrate formed is just redissolved. Float for 3–5 minutes, and upon taking from the bath, place between sheets of clean blotting-paper, which may be used over and over again until their power of absorption is almost destroyed, it being needless to observe that when this stage is reached, the blotting-paper is especially available for the silver waste basket. Paper so prepared has been kept white and good for 9 months, and the results, in the way of the fine, rich, vigorous prints, and ease of toning, leave nothing to be desired.

Toning.—The soda acetate toning bath still holds its own against the many formulæ for toning that have from time to time been published; and deservedly so, as by its use the utmost range of tone can be secured at will, and if the silver be carefully washed out of the prints previous to toning, the acetate bath will keep in order for a considerable length of time, improving in quality with age, if properly strengthened, and not overworked.

For views, a handy and good toning bath is made by neutralising gold chloride with chalk, and using it in the proportion of 1 gr. gold to 10 oz. water; the formula for the soda acetate bath being—

Gold chloride	1 gr.
Soda acetate	30 gr.
Water	10 oz.

Another method, of great ease in preparation and uniformity of action, is given by Werge.

Washing the print after fixing is a very important factor in securing lasting prints, and always receives a deal of attention from the careful photographer.

Constant changes of clean water for 2–3 hours will more effectually cleanse the prints than 12 hours' soaking. A very delicate and ready test for the elimination of soda is given thus by Abney:—

Potassium permanganate	2 gr.
Potassium carbonate ..	20 gr.
Water	1 qt.

The addition of a few drops of this rose-coloured solution to a pint of water will yield a slightly pink tinge. If there be any trace of hyposulphite

present, this will give place to one of a greenish hue.

Lantern Slides on Albumen.—In the production of photographic transparencies, the great difficulty has always been to obtain with certainty a thoroughly satisfactory colour. For uniformity in the matter of colour, no method can excel the carbon process, but for some reason amateurs seem to avoid it. The colour generally admitted to be the most pleasing is a dark, rich sepia brown, first produced by Ferrier and Soulier, of Paris, in their exquisite stereoscopic transparencies on albumen. As lantern slides from photographic negatives are becoming popular, a brief account is given of this method of production, which is unequalled for brilliancy, sharpness, beauty of colour, and certainty of result, while it is surely the most economical of processes. It further has the advantage that the development of the plate can be conducted in a bright yellow light.

Preparation of the Albumen.—Separate the whites from several eggs, remove the germs, and to every oz. of albumen add 2 gr. potassium iodide; when this is dissolved, the mixture must be beaten to a stiff froth, and put aside for several hours to settle; the fluid should then be decanted into a clean glass vessel. If bright and clear, it is fit for use; but if any particles are seen floating about, the albumen must be filtered. To accomplish this, a tuft of wet cotton-wool is pressed evenly into the neck of a glass funnel, and the albumen is poured gently on. It should run through quite clear; if not, the operation must be repeated.

Coating the Plates.—Ordinary cleaned glass plates are used; but if the printing is to take place by contact with the negative, the glasses selected should be the flattest procurable. There is nothing novel in the method of coating the plates. A small quantity of albumen is poured on a plate, and is guided over it with a glass rod. The plan of drying the plates is probably new to most photographers. A common earthenware pan is half filled with dry earth or sand, and on this a couple of handfuls of lighted charcoal are laid, the plate being dried over this in the following manner. A piece of thin wire is twisted at each end into a loop, and bent in form of a bow; the coated plate is supported by fitting 2 opposite corners into the 2 loops, coated side down, and the arrangement is suspended over the fire by a string held in the left hand, a whirling motion being given to the cord by the fingers of the right hand, which causes the plate to spin rapidly round; this throws off the surplus albumen, and the plate is evenly and quickly dried. The plate must not be overheated, or fine cracks will be visible all over the surface. The albumenised plates will keep for any length of time.

To Sensitise the Plate.—The operations of sensitising and developing must be conducted in a yellow light. Sensitising is performed in a dipping bath filled with the following solution:—

Silver nitrate	30 gr.
Glacial acetic acid	30 m.
Water	1 oz.

It is a curious fact that the acid, instead of slowing the plates, rather increases their sensitiveness. An immersion of 30 seconds in the bath is sufficient. A creamy film must not be expected, the plate appearing but little altered by the action of the bath. The plates are washed, to remove the free silver nitrate, and set up to dry. In this condition they will keep for several days.

The Exposure of the Plate.—A full exposure must be given in this process, or cold tones will result. As the plates are very slow, it is advisable to print the transparencies in a frame by contact, and not in the camera. An exposure of 6–8 minutes in the shade may be required, and the employment of an actinometer, as used in carbon printing, is recommended.

Developing the Plate.—Development is performed by pouring the following solutions on the plate placed on a levelling stand, or in a glass dish, which

should not be used for any other purpose.

(*a*)	Pyrogallic acid	2 gr.
	Citric acid	3 gr.
	Water	1 oz.
(*b*)	Silver nitrate	20 gr.
	Citric acid	60 gr.
	Water	1 oz.

Commence the development with (*a*), and add a few drops of (*b*) now and then as required. With a properly exposed plate, the development will be gradual and entirely under control. If the solution becomes turbid or discoloured, it must be changed at once. Any deposit that forms on the surface of the plate may be removed by gently rubbing with a tuft of cotton-wool. If full density is attained before the detail is all out, either the exposure has been too short, or too much silver has been added during development. If, on the other hand, when the detail is fully out, the density is insufficient, too little silver has been used. If, however, the development is skilfully managed and the plate properly exposed, full detail and density will be obtained together.

Fixing and Toning.—The remaining operations may be conducted by daylight. The picture is fixed in a solution of soda hyposulphite made by dissolving 1 oz. hypo in 5 oz. water. After being thoroughly washed, the transparency must be toned in a saturated solution of mercury bichloride; the plate is immersed in this till the whitening action of the solution ceases; it is then removed and thoroughly washed. The plate is next immersed in a solution of ammonia, about 20 minims to the ounce. In this the picture will gradually reappear, and must be carefully watched that it may not get too dark. For this purpose the plate may be removed from time to time, and examined by transmitted light. The colour should be a rich sepia brown. When the proper effect is obtained, the ammonia solution must be washed off under the tap, and the plate dried. The picture will darken slightly in drying, for which allowance must be made. These plates do not require varnishing. The use of mercury has been objected to on the ground that it induces fading; but the plates are quite permanent if properly washed after fixing, and again after removal from the mercury solution.

Glazing Albumenised Prints.—Clean a glass plate well, and rub over it a little powdered talc or wax dissolved in ether. Coat with normal collodion, and dry. Dip your prints in warm gelatine solution which has been filtered; run the same gelatine solution over the collodionised plate, and apply the warm and wet print face downwards. Then the card, dipped in warm water, is well pressed on with a piece of thin waterproof. A stout squeegee or scraper of glass is useful to press out air-bubbles.

Miscellaneous.—

Stripping Films.—Take a developing tray larger than the negative to be stripped, pour in sufficient water to cover, and, for a whole plate, drop in 8–10 drops hydrofluoric acid (the exact quantity cannot be given, as the strength of the acid is constantly diminishing, though kept in a guttapercha bottle); place the negative in the acidulated water, and in a minute or two the film will frill all round the edges and gradually leave the glass. If the operation is slow, add 2–3 drops more of acid, and gently rock.

When the film is loose, hold it at one end, pour off the acid water, and wash by repeated changes of water; this lengthens the film wonderfully, but if the last washing is done with equal parts of methylated spirits and water, it will return to its original size. This may be varied considerably by using more or less spirit. But on no account should undiluted spirit be used, as it makes the film coil out of all control.

Clean a plate with nitric acid—larger than the stripped film—dust with French chalk, polish with a dry cloth, and with a wet one wipe ¼ in. all round, coat with plain collodion, and when set, or even quite dry, introduce under the film. Adjust the film, and with a little

DR. JANEWAY'S TABLE OF THE SOLUBILITY OF PHOTOGRAPHIC CHEMICALS.

Made for the Society of Amateur Photographers of New York.

Abbreviations.—s. soluble; ins. insoluble; sp. sparingly; m. moderately; v. very; alm. almost; dec. decomposed.

Chemicals.	Water. 59° F.	Water. 212° F.	Cold Alcohol.
One part is soluble in	Parts.	Parts.	
Acid, Citric	0·75	0·6	v. s.
Gallic	100	3	m. s.
Oxalic	8	1	v. s.
Pyrogallic	3·5	v. s.	v. s.
Tannic	6	v. s.	v. s.
Alum	10·5	v. s.	ins.
Chrome	10	dec.	ins.
Ammonium, Nitrate	0·5	v. s.	v. s.
Chloride	3	v. s.	sp. s.
Carbonate	4	dec.	m. s.
Sulphocyanate	v. s.	v. s.	v. s.
Bromide	1·5	0·7	sp. s.
Iodide	1	0·5	m. s.
Baryta, Nitrate	8	3	
Cadmium, Bromide	v. s.	v. s.	m. s.
Iodide	v. s.	v. s.	v. s.
Copper, Acetate	15	5	sp. s.
Sulphate	2·6	0·5	ins.
Gold, Chloride	v. s.	v. s.	v. s.
Gold and Sodium Chloride	v. s.	v. s.	m. s.
Iron, Perchloride	v. s.	v. s.	v. s.
Protosulphate	1·8	0·3	ins.
and Ammonia sulphate	3	0·8	ins.
Iodide (Ferrous)	v. s	v. s.	sp. s.
Iodine	7000	..	m. s.
Kaolin	ins.	ins.	ins.
Lead, Acetate	1·8	0·5	m. s.
Chloride	v. sp.	33	ins.
Nitrate	2	0·8	ins.
Lithium, Bromide	v. s.	v. s.	m. s.
Iodide	v. s.	v. s.	m. s.
Magnesia, Nitrate	v. s.	v. s.	m. s.
Mercury, Bichloride	16	2	v. s.
Cyanide	12·8	3	ins.
Potassium, Acetate	0·4	v. s.	v. s.

Chemicals.	Water. 59° F.	Water. 212° F.	Cold Alcohol.
One part is soluble in	Parts.	Parts.	
Potassium, Bicarbonate	3·2	dec.	ins.
Bichromate	10	1·5	ins.
Bromide	1·6	1	sp. s.
Carbonate	1	0·7	ins.
Cyanide	2	1	m. s.
Ferricyanide	3·8	2	ins.
Ferrocyanide	4	2	ins.
Nitrate	4	0·4	ins.
Iodide	0·8	0·5	m. s.
Oxalate	3	v. s.	ins.
Permanganate	20	3	ins.
Sulphate	9	4	ins.
Sulphite	4	5	sp. s.
Sulphide	2	1	sp. s.
Silver, Nitrate	0·8	0·4	m. s.
Oxide	v. sp. s.	v. sp. s.	ins.
Sodium, Acetate	3	1	m. s.
Bromide	1·2	0·5	m. s.
Bicarbonate	12	dec.	ins.
Carbonate	1·6	0·25	ins.
Citrate	v. s.	v. s.	sp. s.
Hyposulphite	1	v. s.	ins.
Iodide	0·6	0·3	m. s.
Nitrate	1·3	0·6	sp. s.
Phosphate	6	2	ins.
Pyrophosphate	12	1·1	ins.
Sulphite	4	0·9	sp. s.
Sulphate	2·8	0·4	ins.
Tungstate	4	2	ins.
Strontia, Chloride	1·88	v. s.	sp. s.
Uranium, Nitrate	v. s.	v. s.	m. s.
Zinc, Iodide	v. s.	v. s.	m. s.
Bromide	v s.	v. s.	m. s.
Chloride	0·33	v. s.	v. s.

care there will be no bubbles. Allow the film to dry, and coat with plain collodion. When this is dry, run a sharp penknife $\frac{3}{8}$ in. from edge of plate, and you have the gelatine film between 2 collodion films, impervious to moisture, quite flat, and may be printed from either side. The acid is so dilute that any developing tray may be used. (*Photo. News.*)

Restoring Faded Photographs.—(1) It is only to immerse the yellowed print in a dilute solution of mercury bichloride until all the yellowness disappears. It is then well washed in water to remove the mercurial salt. If the print be a mounted one, it is by no means necessary to unmount it previously to treatment. All that is required in this case is to keep it in intimate contact for a time with blotting-paper charged with the bichloride; indeed, this is the plan originally suggested by Barnes. By the bichloride treatment no lost detail is actually restored, as some have imagined. It is simply that the sickly yellow colour which, as it were, buried the delicate half-tints, or what remains of them, is removed, and thus renders the picture bright and clear. Pictures which have been treated with the mercury always possess a much warmer tone than they did originally, as the purple or black tones give way to a reddish brown or reddish purple — more or less bright according, probably, as gold or sulphur had been the principal toning agent. Here a question very naturally arises with regard to the future permanence of pictures which have been thus "restored," seeing that negatives intensified with mercury or transparencies toned with it are so prone to change. In answer to this we may mention that they appear to be permanent—at least that is our experience with some that have been done for many years. There appears to be no further loss of detail, and the whites retain their purity. Indeed, since undergoing the treatment with mercury, no alteration is yet perceptible. (*Br. Jour. of Photo.*)

(2) The following method is simple and in most cases quite effective:—Put the card in warm water until the paper print may be removed from the card backing without injury. Hang up the paper in a warm place until perfectly dry, and then immerse it in a quantity of melted white wax. As soon as it has become thoroughly impregnated with the wax, it is pressed under a hot iron to remove excess of the latter, and rubbed with a tuft of cotton. This operation deepens the contrasts of the picture and brings out many minor details previously invisible, the yellowish whites being rendered more transparent, while the half tones and shadows retain their brown opaque character. The picture thus prepared may then be used in preparing a negative which may be employed for printing in the usual way.

Printing a Positive from a Positive.—Cros and Vergeraud have worked out a process for obtaining images so as to have a positive impression from a positive plate, and a negative print from a negative original. The process is based on the following circumstances: The easy reduction of soluble bichromates mixed with certain organic substances, and the relative insolubility of silver bichromate. Suitable paper is covered with a solution of 2 dr. ammonia bichromate, and 15 dr. grape sugar, dissolved in 100 dr. water; when dry, it is exposed to light under a positive. As soon as the yellow paper becomes grey, it is removed, and immersed in a 1 per cent. silver bath, to which 10 per cent. acetic acid has been added. The image will immediately appear of a ruddy hue, due to the silver bichromate. The print, on being washed, retains the red impression of the insoluble bichromate, which becomes dark brown on exposure to sunlight. On submitting the print when dry to the fumes of sulphuretted hydrogen, or dipping in a solution of copper sulphite and potash, it becomes black. The latter process is preferable. (*Photo. News.*)

Reducing Over-printed Proofs. — A simple and certain method of reducing over-printed proofs has been one of the

wants long felt by all photographers. It is well known that in every photographic establishment even the most careful printers cannot always be sure of getting the exact depth of tone required, and proofs occasionally get over-printed. Of course prevention is better than cure; but, when a remedy is necessary, the method here described answers admirably. Potassium cyanide totally destroys the print, even when used moderately strong. By using a weaker solution, it is well under control, and the exact depth can be readily obtained; but during the washing to remove the cyanide, the action of the latter continues, and will spoil every proof. Several methods to arrest the action of the cyanide have been tried without success. It was then proposed to use the cyanide in such a weak state that but little should be held in the paper, only sufficient to reduce the print to the required depth; for this purpose, make a bath of only 4 drops saturated solution of cyanide to 1 pint water. The prints immersed at first show no signs of getting lighter, but after about an hour the most perfect results are obtained with prints considerably over-printed. With lighter pictures, a less time is required. Proofs treated in this way lose nothing of their tone during the after-washing, which should be thoroughly done, and, when dry, retain all the brilliancy of an ordinary print.

Photographing by Magnesium Light.—Some experiments have been recently published on the use of bottles of oxygen in which to burn fragments of magnesium ribbon, to take portraits by the magnesium light. An objection is the trouble and cost of making the oxygen, and that means have to be adopted to diffuse the light near its source. The objection to burning the ribbon in air is that the exposure is longer, and the burnt ash has a tendency to drop off and put out the light before the selected length of metal is consumed.

Some years ago, W. H. Harrison overcame the difficulties by the adoption of one part of the principle of Larkin's magnesium lamp. The method may be thus explained. On the top of a firm and solid table is placed a base-board supporting a wooden upright some 7–8 ft. long, consequently reaching nearly to the ceiling of the room. At the top is a kind of little brass funnel with no neck, and a large opening where the neck should be. This brass inverted cone was no larger than an egg-cup, and its lower opening was about as large as a fourpenny piece. A tin spirit-lamp, with a horizontal neck and flame, is placed below, so that anything falling through the funnel must pass through the flame, yet just miss touching the wick. The combustible substance was magnesium powder mixed with sand. One thimbleful of the powder, for instance, is mixed with two of sand with a spoon or bit of wood on a sheet of paper; then, the sitter being in position and all being ready, the mixture is poured all at once into the funnel. A long sheet of flame of one or two seconds' duration is the result. If the picture prove over-exposed, the proportion of sand has to be increased in the next trial, or that of the magnesium powder correspondingly diminished. When once the right proportions are known, portrait after portrait can be produced, properly exposed with dead certainty. No cap is necessary to the lens, provided a candle only is used for the normal illumination of the room, and it is not placed so that an image of it can be thrown by the lens into the camera. The proportion of magnesium powder regulates the proper exposure. At first there was a difficulty, and one only, with this simple apparatus, and that was that the aqueous vapour from the flame condensed on the lower parts of the brass cone, and the powder stuck to the neck of the wet funnel, sometimes blocking it and arresting the flow of illuminating material altogether. The neck of the funnel was therefore cut off, and the lower opening of the cone made rather large. It would be an improvement to use something on which aqueous vapour has less tendency to condense than upon bold brass. The brass, however, was subsequently kept hot by fixing

the spirit-lamp nearer to it than in the first experiments.

The larger the proportion of magnesium in relation to the sand, the longer the flame and the shorter its duration. With a very rich proportion, it is possible to have a flame 7–8 ft. long. The long flames give the necessary diffusion of light, and a white sheet on the opposite side of the sitter improves the shadows. The finest artistic effects of light and shade on the countenance of the sitter can be obtained by this method when the lamp is placed in the proper position.

The sitter need not be fatigued with focussing operations. A candle placed where his face will come will do to focus upon. In fact, it is a capital method for the comfort of the sitter, who must not look in the direction of the coming flame, lest his eyes be dazzled by its magnificent flash, which, however, lasts but a second or two. (*Brit. Jour. Photog.*)

Paper Negatives.—Use Morgan and Kidd's ordinary enlarging paper for negatives, and a Rouch's patent 10 by 8 camera with an ordinary dark slide, in which fix slips of copper $\frac{3}{8}$ in. wide for the paper to rest on. Lay a sheet of sensitive paper face down, then a sheet of opaque orange paper, then another sensitive paper, and so on, alternately, until you have 10–16 sheets of each kind, and on top place a sheet of glass to keep them flat.

The exposure is long—being about the same as for a wet plate. After exposing, place the dark slide in a changing-bag 28 in. by 12 in. by 5 in., made of 3 thicknesses of twill, and having sleeves in the 5-in. sides near one end, and a slit at the other end, which rolls over and is covered by the focussing-cloth, and is perfectly light-tight. Remove the exposed sheet, and the opaque paper next it, and place them at the back of the glass, which operation takes less than a minute, and can be done anywhere.

Develop at night, using orange paper and cherry fabric round a lamp. The paper is immersed in water in a glass dish for about a minute, and for a 10 by 8 plate mix the developer:—

Pyrogallic acid	4 gr.
Ammonia bromide ..	$2\frac{1}{2}$ gr.
Ammonia	6 drops
Water	2 oz.

Turn the paper face upwards, and pour off the water, when the paper will be quite flat. Pour on the developer, and the details should be out in 1 minute at the most; but care should be taken not to push the development too far, as the shadows should be quite white. Wash, fix for 10 minutes in hypo 1 to 5; wash, soak for 10 minutes in a saturated solution of alum, and wash again. If the negative is stained yellow, use 10 oz. saturated solution of alum, $\frac{1}{2}$ oz. citric acid; after which, wash.

There are 3 ordinary ways of making the paper transparent:—(1) With white wax, as in the old paper process. (2) 4 parts castor oil, 1 part ether, brushed on the back; then warm, and when cool, with a rag take off the superfluous oil, and warm again. (3) Brush over the back of the negative a mixture of 1 part Thomas's rubber solution, $\frac{1}{2}$ part pure benzole, $1\frac{1}{2}$ part Canada balsam. 10 by 8 plates weigh 8–10 lb. a dozen, including packing, whereas 9 doz. paper negatives weigh less than 4 lb., which makes an immense difference. Then, with one wet plate, slide, and a changing-bag weighing a few ounces, you can take 12–16 negatives; the whole set of apparatus taken in the field weighing only 12–15 lb.

Photographing Paper Photographs.—In copying paper photographs the granular texture of the paper invariably injures the copy, making it appear to be covered with whitish dots. A method practised by Denier, a Russian photographer, enables one to obtain a perfect copy in which all granularity is avoided. On copying the original it is illuminated with a strong side light, so as to minimise the grain as much as possible to begin with. The negative is made tolerably vigorous, and then slightly retouched. In printing (using a registering printing frame),

when the impression has attained somewhat about half its proper depth, it is removed from the negative, and a couple of thin films of gelatine—such as those used in packeting confectionery—are placed upon it, one of those films being tinted a pale blue, and the other colourless. The half-printed sheet is next replaced over the gelatine sheets in exactly the same position as it previously occupied, and the printing is continued until it is dark enough. By this method, the details are printed first, while the second printing blurs and softens the picture, and prints out the granularity. An ordinary printing frame may be converted into a registering frame by placing a piece of sheet glass in the front, and laying upon the negative, which must have one corner and two sides abut against the interior sides of the frame. The other edges of the plate should be wedged between the sides of the frame. The negative being rigidly secured, the paper must be cut so that its top and one side, at least, shall form exactly a right angle. In replacing the paper in the frame, if care is taken that the 2 edges accurately fit the corner of the frame, it may be removed, the films inserted, and the paper again replaced, provided that the same edges strike the sides of the frame, without interfering with the result or over-blurring the picture. Very soft and peculiar effects may be produced by this process.

Another method is to place the photograph in a strong side light, and in making half the time of exposure with the image exactly in focus on the ground glass, then capping the lens and moving the back of the camera slightly within the focal point, so that the image will be a little out of focus; then to expose one quarter of the time, recap the lens, and expose the last quarter with the rear of the camera slightly beyond the focal point. A negative will be produced in which all appearance of granularity is destroyed, and from which prints may be made direct without the necessity of double printing.

A Photographic Print upon Paper in 5 Minutes.—It is sometimes desirable to produce a positive upon paper in much less time than is possible by the ordinary process, in which manner it takes not less than 12 hours to complete a good photograph. The following process possesses some interest.

The following solution is prepared in a stoppered bottle, and protected against light:—

Distilled water	125 dr.
Citric acid	7½ dr.
Iron and ammonia citrate	4 dr.
Conc. liq. ammonia ..	7½ dr.

After shaking the bottle until everything is dissolved, the solution is filtered. Now fasten a piece of positive paper with clamps upon an even board, and cover the same with the above solution, applying a flat camel-hair brush up and down the paper, until it is evenly coated, after which manipulation it should be dried in the dark.

The paper prepared in this manner will have a deep yellow tone. The printing is done, as usual, in a printing frame; but care must be taken that the action of the light commences simultaneously with the copying. The exposure should be very short, and continue only until the principal lines of the picture are visible. After this, the picture is placed in a flat dish, the exposed side up, and then moistened with distilled water, when the following developer is to be poured upon it:—

Distilled water	125 dr.
Cryst. silver nitrate ..	4 dr.
Conc. liq. ammonia	2 dr.

This solution must be filtered, and will, after application, bring out all the details of the picture, but with a disagreeable red tone. (This developing solution, by shutting off the light, can be kept for a long time, and, by filtering again when wanted, can be used repeatedly.) Afterwards the picture is carefully washed in running water, and fixed in the following bath:—

Distilled water	125 dr.
Soda hyposulphite	7½ dr.
Aqua regia	2½ dr.

In this bath the picture remains several minutes, until it has changed to a deep purple tone, after which it is put into a dish with warm water, and washed, and then rinsed 3 or 4 times in a change of water. Now it is placed between a few sheets of blotting-paper, and then dried over a spirit lamp. According to the quantity of aqua regia and soda hyposulphite in the fixing bath, the tone can be changed. The tone can likewise be modified by adding a little pyrogallic acid. This copying process can be also used for enlargements.

Paper Negatives.—At a recent meeting of the London and Provincial Photographic Association, W. Turner gave the following as his method of making paper negatives: The picture or drawing to be copied is made translucent by means of lard diluted with turpentine—1 part lard to 3 of turpentine, the mixture is then boiled for 3 minutes, which kills the grease, and it is then rubbed over the drawing. When the surface is dry, the drawing is placed in a printing frame with sensitised silver paper, and a negative is made, which is fixed in an old hypo bath rich in silver, and washed in the usual way.

The plain paper is prepared by floating Saxe paper on the following:—

Sodium chloride	200 gr.
Gelatine	30 gr.
Water	20 oz.

Dissolve the gelatine and chloride separately, and mix; float 3 minutes. When dry, sensitise by floating 1–2 minutes on the following:—

Silver nitrate	1 oz.
Citric acid	1 dr.
Water	14 oz.

He states that the paper will keep good for 6 weeks.

Enlarging on Argentic Paper and Opals.—The process of making gelatino-bromide of silver prints or enlargements on paper or opal has been before the public for some years now, and cannot be called new; but still it is neither so well known nor understood as it deserves to be. There is no other enlarging process capable of giving better results, while the ease and rapidity with which enlarged pictures can be made by it are great. To make an enlargement on a 12 by 10 opal, using a sciopticon burning paraffin, an exposure for 2½ minutes is sufficient. Most effective enlargements can be made by the paper process also; indeed, as a basis for colouring, nothing could well be better. Artists say, after a few trials, they prefer it to anything else, while excellent and effective plain enlargements are easily made by it if only carefully handled. A very good enlargement is made by vignetting the picture with the opal, then squeezing it down on a clean glass, and afterward framing it with another glass in front, when it will have the appearance almost equal to an opal. To make sure of the picture adhering to the glass, however, and at the same time to give greater brilliancy, it is better to flow the glass with a 10 or 15 gr. solution of clear gelatine before squeezing it down. The one fault or shortcoming of the plain argentic paper is the dulness of the surface when dry, and this certainly makes it unsuitable for small work, such as the rapid production of cartes or proofs from negatives wanted in a hurry; the tone of an argentic print is also spoken of sometimes as being objectionable; but probably it is not so much the tone as the want of brilliancy that is the fault there, and if once the public were accustomed to the tones of argentine paper, they might possibly like them twice as well as the purples and browns with which they are familiar, provided they had the depth and gloss of a silver print. Some time ago, acting on a suggestion made by the editor of the *Photographic News*, Goodall set about trying to produce this result by enamelling the paper with a barium emulsion, previous to coating it with the gelatinous silver bromide. His experiments were successful, and he now prepares an enamel argentic paper on which the prints stand out with brilliancy equal to those on albumenised paper.

Mention has already been made of the great ease and facility with which an

argentic enlargement may be made, as compared with a collodion transfer, for instance; but there is another and more important point to be considered between the two, and that is, their durability and permanence. Now with regard to a collodion transfer, unless most particular care be taken in the washing of it (and those who have made them will well know what a delicate, not to say difficult, job it is to get them thoroughly freed from the hypo. and at the same time preserve the film intact), there is no permanence in a collodion transfer, and that practically, in 9 cases out of 10, they have the elements of decay in them from the first day of their existence. At least in Glasgow, where an enormous business has been done within the last few years by certain firms in the club picture trade (the club picture being a collodion transfer tinted in oil or varnish colours), there are literally thousands of pictures for which 30s. or more has been paid, and of which the bare frame is all that remains. A collodion transfer cannot be made even comparatively permanent, unless an amount of care be taken in the making of it which is neither compatible nor consistent with the popular price and extensive output.

Argentic enlargements, setting aside every other quality, are the most permanent pictures that have ever been produced. Chromotypes and other carbon pictures have been called permanent, but their permanence depends upon the nature of the pigment employed, and associated with the chromated gelatine in which they are produced, most of the pigments used, and all the prettiest ones, being unable to withstand the bleaching action of the light for more than a few weeks. Carbon pictures are therefore only permanent according to the degree in which the colouring matter employed is capable of resisting the decolorising action of light. But there is no pigment in an argentic print, nothing but the silver reduced by the developer after the action of light; and that has been shown to be of a very stable and not easily decomposed nature; while if the pictures are passed through a solution of alum after washing and fixing, the gelatine also is so acted upon as to be rendered in a great degree impervious to the action of damp, and the pictures are then somewhat similar to carbon pictures without carbon.

Defects and failures are sometimes met with in working this process. There are frequent complaints of want of purity in the whites, especially in vignetted enlargements; this almost always arises from one or other of the 2 following causes:—

(1) An excess of the ferrous salt in the ferrous oxalate developer; and when this is the case, the yellow compound salt is more in suspension than solution, and in the course of development it is deposited upon, and at the same time formed in, the gelatinous film. The proportions of saturated solution of oxalate to saturated solution of iron, to form the iron oxalate developer, that has been recommended by the highest and almost only scientific authority on the subject—Dr. Eder—are 4–6 parts of potassic oxalate to 1 of ferrous sulphate. Now while these proportions may be the best for the development of a negative, they are not the best for gelatine bromide positive enlargements; indeed, potassic oxalate should not have more than $\frac{1}{8}$ of the ferrous sulphate solution added to it, otherwise it will not hold in proper solution for any length of time the compound salt formed when the two are mixed.

(2) The other cause is the fixing bath. This, for opals and vignetted enlargements especially, should always be fresh and pretty strong, so that the picture will clear rapidly before any deposit has time to take place, as it will be observed that very shortly after even one iron developed print has been fixed in it a deposit of some kind begins to form, so that although it may be used a number of times for fixing prints that are meant to be coloured afterward, it is best to take a small quantity of fresh hypo for every enlargement meant to be finished in black and white. The proportions are 8 oz. to the pint of water.

Almost the only other complaints are traceable to over-exposure or lack of

intelligent cleanliness in the handling of the paper. The operator, after having been dabbling for some time in hypo, or pyro, or silver solution, gives his hands a wipe on the focussing cloth, and straightway sets about making an enlargement, ending up by blessing the manufacturer who sent him paper full of black stains and smears. Argentic paper is capable of yielding excellent enlargements, but it must be intelligently exposed, intelligently developed, and cleanly and carefully handled.

Light for the Dark Room.—The use of a yellow instead of a ruby light for those photographic operations which require what is called a dark room, has been spreading considerably. It is, however, sometimes assumed that although a yellow light may safely be used for developing, a red or ruby coloured illumination is necessary for the preparation of the plates.

If, however, as many experiments seem to show—notably those of J. R. Sawyer, described at the June meeting of the Photographic Society of Great Britain—yellow and orange light have less effect upon a sensitive plate in proportion to illuminating power than red light, it is difficult to see how the latter should be safer or better for any part of the work of plate making; and the practice of some of our most advanced workers is to use yellow light alone for all photographic operations. W. Cobb, whose views of London are amongst the most remarkable instantaneous photographs that have been seen, and who has succeeded in preparing plates of most extraordinary rapidity, recently stated that he used yellow light in his coating room, and found that even a prolonged exposure to its rays had not affected plates which were exposed to it.

Of all the yellow mediums tried, none, when used alone, gives at the same time so strong and safe a light as that which is known as golden fabric. It is so very translucent that several thicknesses may be used, and still sufficient light transmitted for satisfactory working; 4 folds over a small window will be found to afford an ample light; whilst if the sun shine upon the window, extra thicknesses may be applied, and still far more light to work by, will be admitted than with the lauded ruby. For artificial light, 1, 2, or 3 thicknesses may be used, according to the power of the light and the sensitiveness of the plates to be dealt with.

It is obviously desirable with this, as with all textile fabrics, to have a sheet of glass in front, to protect it from splashings; and the outer fold should be examined occasionally, and, if at all faded from exposure to light, changed. (W. E. Debenham.)

Mounting Prints. — Until improvements in photo-mechanical printing methods enable us to economically and conveniently impress the photographic image directly upon cardboard, the work of mounting prints will form a considerable item in the labour account of the photographer; as the public look with but little favour upon an unmounted picture, the number sold is comparatively small. A mounted photograph is seldom so flat and even as the original card, because the albumenised paper, expanded by the moisture of the adhesive material used, contracts in drying, and distorts the card mount; this distortion being generally so considerable, that in the case of a print mounted upon a large card, a decided concavity of the picture results, while a small card nearly covered by the photograph is generally drawn either into a gutter or a bow-like form. These disadvantages can be readily overcome by adopting the simple and easy expedient of gumming the prints, allowing them to dry, and then causing them to adhere to slightly damped mounts by the application of considerable pressure. The work of gumming the back of the photographs can be very quickly performed if a broad brush is used, but as the gumming of paper is now a distinct trade in London, it is more advantageous to send them to be gummed, more especially when the sheets are printed upon whole. A ream of paper, the same size as the ordinary sheets used for photographic purposes ($17\frac{1}{2}$ by $21\frac{1}{2}$), can be gummed in London for about 10*s.*, this

sum including the gum. The gummed pictures are next trimmed in the usual way, when all is ready for the work of mounting.

A card is very lightly damped on the face with a sponge, the gummed photograph is placed in position, and the whole is quickly run through a lithographic or a roller press. Far less moisture is required than might be supposed, as the pressure brings to the surface that water which has soaked into the card, and the mounted photograph, when taken from the press, is, to all appearance, as dry as if it had not been damped at all; and, what is more important, it has no tendency to curl. A smooth lithographic stone forms the best basis upon which to lay the print when the pressure is applied, and a sheet of smooth card or glaze board should be laid over the picture before the leather tympan is closed down upon it. Assuming the pictures to be already gummed, about 400 per hour can be mounted by this method, and it must be remembered that the effect of the pressure is almost equivalent to rolling. The method referred to has long been in use by collotype printers, in this country and abroad, for mounting their pictures. A small lithographic or autographic press, suitable for work up to about 12 by 10, can be obtained for a very moderate sum. (*Photo. News.*)

Paper Pan.—First cut out a block of wood the exact size and thickness of dish required. Then take a sheet of cartridge paper, paste it with flour paste and rub in the paste well, letting the paper be thoroughly soaked with it. Then place the paper evenly on the wooden block, turn down the edges smoothly and double the corners back, rubbing them down well. Be very particular with the first sheet, because if you get that smooth, the rest is easy. Follow with another sheet of cartridge paper, turning the surplus or slack paper at the corners, in the opposite direction to the last. Follow with 5 or 6 sheets of old newspaper in the same way, and cap with another sheet of cartridge. Put the block with the paper on it into an oven, and bake till dry. Then take out the block and trim the edges. Paint the outside of the paper dish with varnish. Pour some varnish inside the dish and let it soak in, and then pour off the surplus. Bake in the oven again. After the varnish is hard and dry, warm the dish until it is hot enough to melt paraffin wax. Pour some melted paraffin into it, and tilt it about till the bottom and sides are evenly covered; pour off the surplus, and when dry you can use for toning, developing, or even silvering paper. Of course the above is only recommended as a substitute for glass or porcelain when the latter cannot be readily obtained. Paraffin alone may be used if you like. (F. Whitehead.)

Testing a Lens.—To be thoroughly successful in photography, it is of the utmost importance that the operator should be perfectly familiar with the lens he is working with. A lens should be examined and tested for any serious defects, as well as for the determination of its capabilities. Small air-bubbles, spots, or scratches on the glass, are of but little consequence, although scratches should be filled up with black varnish to prevent diffusion of light. It is important, however, that the glass should be highly polished, in order to secure brilliancy in the picture and freedom from irregular reflection.

To find the Focal Length.—Focus a distant object on the ground glass. Now focus another object so near that the image is as large as nature. The difference between the 2 positions is the focal length of the lens. To find the optical centre of a combination of lenses, Abney recommends the following plan. Place 2 rods (10 yd. apart) at a spot exactly 50 yd. from the front of the camera, which must be perfectly level, and in a line with one of the rods, and at right angles to the line joining the two rods. Now focus the nearest rod accurately on to a pencil line drawn in the centre of the ground glass. Then the equivalent focal length =

$$\frac{\text{Distance of ground glass from nearest rod} \times \text{apparent distance apart of rods on ground glass.}}{\text{Actual distance of rods apart} + \text{their distance apart on glass.}}$$

The equivalent focal length measured from the ground glass along the axis of the lens will give the *optical centre*.

Test for Distortion.—Rule a square on a piece of paper and place it at a distance of not less than 5 times the focal length of the lens. Examine the amount of curvature of the lines on the ground glass.

Test for Astigmatism.—Rule a piece of paper, with both horizontal and vertical lines, and focus it on to the ground glass, so that the image falls near the margin. Either one or the other system of lines will be indistinct. Closely connected with this defect is *spherical aberration*, which causes general blurring of the whole image, and *curvature of the field*, which causes marginal blurring when the centre is in focus, and *vice versâ*. These defects, due to the spherical forms of lenses, are more or less present always, but may be diminished by using smaller stops.

Depth of focus depends on the size of the angle made by the rays, and therefore increases as the aperture diminishes, and also as the distance of the object increases. When used for pictures $\frac{1}{20}$ natural size, the depth of focus is 400 times greater than when used for pictures the size of nature.

Angle of View.—Take the equivalent focal length and measure the greatest breadth of the picture, or of the circle of light, on the ground glass. Transfer the latter length on to a sheet of paper, and from the middle of the line so obtained erect a perpendicular equal to the focal length. Join the ends of the base with the summit of the perpendicular, and the angle so formed is the angle of view.

Size of Plate Covered.—This is any rectangle having for its diagonal the diameter of the circle of light on the ground glass. For near objects, a smaller size will be sharply covered than for distant objects.

Chromatic Aberration.—To determine whether the optical and chemical foci coincide, a focimeter is necessary. This may be roughly constructed by pasting strips of thick paper, so as to form a series of steps. Now number each step, and focus accurately on to the central one. On development, if any other number is more distinct than the central one, a chemical focus is present.

Flare-spots.—This is a circular patch of light appearing on the ground glass, in a line with the axis of the lens. It is owing to the image of the diaphragm coinciding with the focal distance of the lens, and may be remedied by altering the position of the diaphragm.

Brilliancy of the Image.—If f F are the focal lengths of 2 lenses, and a A their apertures, their illumination varies as

$$\frac{f^2}{a^2} : \frac{F^2}{A^2}$$

Thus it is important to estimate correctly the effective aperture of a lens. This may be done accurately thus:—Focus any distant object on to the ground glass, which is then removed and an opaque board, with a small hole in the centre, is substituted. A lamp is now put behind this hole, and a piece of transparent paper is placed over the front of the lens. The diameter of the bright spot on the paper is the effective aperture for that particular diaphragm. The time of exposure varies inversely as the fractions

$$\frac{f^2}{a^2}, \frac{F^2}{A^2}$$

but it must be remembered that the nature of the glass will also influence the quantity of light admitted by a lens. (J. V. Elsden.)

Photographing on Wood.—Among the many published formulæ for photographing on wood, nearly all are defective at one vital point; that is, the block becomes wet during the operation. In this respect, engravers' boxwood is peculiar, and to wet a block is generally to spoil it. In preparation, the logs are sawn transversely into wheels about 1 in. thick, and planed down to type height. As the trees are of comparatively small diameters, it is often necessary to glue several pieces together to obtain a block of a given size. To salt and sensitise a block in the usual

way wets it, of course, and the final toning and fixing gets it thoroughly soaked. The surface on which the engraver works is endwise the grain of the wood, the pores of the wood running straight through. Water quickly penetrates these pores, thereby causing the block to swell and warp, and, when subsequently dried, it very often does not regain its former level condition, which is essential. The small pieces composing the whole often expand unequally, thereby tearing them apart at the joints. Besides this, the glue in the joints becomes softened, making it liable to break in the press. The mere sensitising of the surface will often cause the block to warp so much that it is impossible to get good contact in the printing frame. Rinsed negatives are required also, which is another trouble.

There are 2 ways of printing on wood which give good results, and do not damage the block in the least. (1) From a negative of the subject desired, make a clear, thin positive on glass, by the wet collodion process. The positive should be of the proper size, on clean glass, without the substratum. Tone and fix as a transparency, and lay in a dish of water containing a small percentage of sulphuric acid, to loosen the film. The film will soon become so loose that it can be easily stripped from the glass and transferred to the block. To do this safely, lay on the film a piece of wet albumenised paper a little larger than the glass. Press out the bubbles and surplus water carefully, then turn back one corner of the paper, and it will come off, bringing the film with it. Have the block smoothly whitened with Chinese white in gum-water, and the surface slightly damp. It is now easy to transfer the film to the wood and remove the paper, when the block must be allowed to dry spontaneously.

(2) Another way to print on wood is by a sort of photo-lithograph process. Coat paper with a thin, uniform coat of gelatine in warm water. Dry, and float a short time on a weak solution of potash bichromate in water. Dry again, and expose under a negative till all the details are visible. Roll the entire surface of the print with a printers' roller charged with lithographic transfer ink thinned with spirits of turpentine. Soak the paper in a dish of tepid or warm water until the ink can be removed by rubbing gently with a soft sponge. All the ink, except the lines composing the picture, can be removed, when the print should be laid face down on the whitened block, and subjected to a heavy pressure in a common letterpress. The paper can be easily removed by wetting the back.

(3) Another application of photography as a help to the engraver was discovered by the writer. Procure hard rubber, in smooth, black, polished sheets about $\frac{1}{8}$ in. thick. These are to be cut to the proper size, cleaned, and albumenised the same as glass for negatives. The rubber-plate is covered with collodion, sensitised in the bath, exposed in the camera, and developed in the usual way of making a negative. In fact, the whole operation is exactly the same as in making a ferrotype, on rubber instead of an iron plate, and a ferrotype bath and collodion are well adapted to the rubber. When a clean, sharp image is obtained, it is fixed in cyanide, varnished with a thin transparent varnish, and dried by a gentle heat. The plate is now ready for the engraver, who will have a fine smooth surface and a clean drawing to work on. (T. C. Harris.)

(4) The following method, by which F. E. Ives says he has put hundreds of photographs on wood for engravers, gives better satisfaction than any he has seen published. Notwithstanding the considerable amount of wetting which the block receives, there is never any complaint of injury therefrom, unless the blocks are very green.

A block—say 3 by 4 in.—is whitened by putting on 2 or 3 drops of thick salted albumen, then sprinkling on a little pure dry white-lead (zinc white must not be used), and spreading and mixing them with the ball of the hand until the coating is thin, even, and smooth. Rub from the middle of the

block, with alternate strokes to the right and to the left, occasionally turning the block to make the strokes crosswise, until the coating is so nearly dry that the last gentle strokes serve to smooth it almost to a polish. It requires some skill to perform this operation successfully, and it cannot be well described. If rightly done, the coating will be thick enough to make a bright print, but will not chip or give any kind of trouble to the engraver, not even for the very finest work. The correct amount of albumen and white-lead, as well as the proportion of one to the other, must be learned by experience, and will be found not to be the same for all blocks.

When the coating is perfectly dry, it may be polished with a brush, then sensitised by covering the surface for exactly 2 minutes with a 60-gr. solution of silver nitrate. Rub off with a blotter, and when perfectly dry, fume 20 minutes with ammonia. After printing (under a reversed negative), wash with running water not more than 30 seconds, and then tone and fix at once by placing face down upon a solution of soda hyposulphite (1 to 6), to which has been added a pinch of soda carbonate and a little gold chloride; 20 minutes' fixing is right, after which the block is washed, and allowed to dry, when it is ready for the engraver.

The salted albumen is made by adding 80 gr. ammonium chloride to the well-beaten white of 6 fresh eggs; a few drops of ammonia may be added, but no water. Blocks which are white and porous from over-seasoning must be coated twice with the albumen, the first application to fill up the pores of the wood, and the second (after the first has dried in) to prepare the surface. The thick albumen rubbed into the face of the block, and then coagulated by the silver nitrate, preserves the wood from injury. In skilful hands, the method is quick and reliable, and the results are very satisfactory.

(5) Underlying the whole system of photographing upon wood is this principle—nothing must remain on the surface which is capable of clogging the point of the graver, hence the vehicle in which the composition of the photographic image is applied must be of the most attenuated nature possible. Again, it is easy to imbue the surface of the wood itself with the chemicals by which the image is formed, but difficult to prevent the wood that has been subjected to such treatment from becoming rotten or friable, by which, fine delicate lines crumble and give way under their construction, owing to the pulverulence of the surface. Firmness and closeness of texture are essential requisites in the surface that has to be operated on by the engraver.

Collodion, gelatine, starch, and other media have all been employed as vehicles, combined with silver salts of various kinds, and chromates. Those processes known generically as "dusting on" have also conduced to the successful application of photography to wood, together with the simpler system of rubbing over the surface with a sensitive powder, made to adhere with sufficient tenacity to ensure its not becoming dislodged by any after treatment—such powder being capable of being impressed by an image under the negative. This enumeration, incomplete as it intentionally is, serves to show how much ramified has become the important art of photographing on wood.

The first process to describe is one involving the rendering of the wood sensitive with silver chloride, without any rottenness arising. The surface of the wood is first of all whitened by being well rubbed with a paste composed of finely powdered white-lead and a little water. This procedure is sometimes varied by the use of alcohol. When dry, the surface receives a coating of an exceedingly weak solution of mastic and guttapercha in benzole. The following strength will suffice:—

Guttapercha	3 gr.
Mastic	3 gr.
Benzole	1 oz.

This does not leave any film on the wood, but serves merely to fix the white pigment.

The next operation is an unpleasant one, as it necessitates the working with albumen which, before being used, must have passed into a state of putridity. Beat into a froth the whites of as many eggs as may be found desirable, and for each egg employed add 4 gr. sodium chloride and 18 m. strong ammonia. Keep this standing in a warm place for about a month, and add water to make up the loss from evaporation. When putrid, filter and apply to the surface of the wood by means of a brush. After being dried, apply, by the same means, a 45-gr. silver solution. The block, thus sensitised, is exposed under a reversed negative until printed sufficiently deep, after which it is washed by means of a broad camel-hair brush, and toned and fixed in the usual way.

The negative may be used in a reversed position. Of course, when the negative is taken expressly for the purpose of being employed in connection with engraving, the photographer will take care that it be reversed or non-reversed to suit his special purpose; but in the case of pre-existing collodion negatives the case is different.

Let us suppose that a collodion negative several years old, and well varnished, is required to produce a reversed print. The first operation is to remove the varnish. This is best effected by pouring over the surface a little of the following mixture:—

Caustic potash	..	2 parts
Alcohol	..	2 ,,
Water	..	20 ,,

This must be poured off and on until the varnish is dissolved, when the surface is well washed with water and allowed to become dry. The plate is now placed on a levelling stand and coated with a very thin solution of rubber in benzole, followed, after being dried, by a coating of transfer collodion composed of alcohol and ether, 2 pints of the former to 1 of the latter, in which is dissolved 1 oz. each of castor oil and guncotton. The object of the coating of rubber is to prevent the transfer collodion from acting upon the collodion that contains the image.

When the transfer collodion is quite dry, which may take one or even several hours, it is gently warmed to dispel any milkiness, should such exist. A knife is next run round the margin so as to cut through the film, and the negative is placed face upward in a flat vessel of water. Ere long the film will be seen to become loosened on the glass, and in a short time it will become altogether detached. It must then be placed between 2 sheets of blotting-paper to be dried, after which it is kept in a folio for use.

In printing from a pellicular negative prepared as described, the picture may be either reversed or non-reversed according to the side placed next to the paper, and both classes of prints will be equally sharp.

The wet collodion process is applied to this purpose by a transfer system which does not injure the surface of the wood by the action of chemicals. Its practical nature may be deduced from the fact that it was by this agency the large portrait of Prof. Huxley, together with similar portraits of other eminent men of science, which appeared some time ago in a leading London illustrated newspaper, were placed upon the wood ready for the engraver. The process is mainly that of Grüne, subjected to such modifications as were found necessary in getting it brought to a successful state of working.

It is first of all necessary, by means of a copying camera, to produce from the negative a transparency the exact size which the engraving is required to be. The knowledge required to produce a transparency, together with a suitable camera for the purpose, is assumed as being in the possession of the operator. The collodion must be prepared with soluble cotton, made at a low temperature to ensure its being tough or skinny, and it is so far fortunate that cotton of this class can be readily obtained. The mechanical characteristic of the collodion is that it shall be tough; its photographic peculiarity being that it

shall not yield a dense image, but one that is very soft and transparent in even the deep blacks. The following is a formula which, we were informed by a professional photographer on wood, who is also a practical engraver, invariably gave the best results.

Plain Collodion.

Alcohol	900	parts
Ether	1800	„
Pyroxyline	60	„

Iodised Collodion.

Plain collodion (as above)	700	parts
Alcohol	450	„
Ether	150	„
Cadmium iodide	14	„
Sodium bromide	10	„
Alcohol	100	„

To dissolve the sodium bromide, rub it in a mortar with a few drops of distilled water, then add the alcohol last mentioned in the formula, and finally the cadmium iodide.

We have given the proportions in "parts," which any photographer may interpret by gr. or dr. so as to suit his own idea as to the quantities desirable to be made at a time. But we must make one observation, which is this: It is necessary that the collodion be tough; but seeing that the longer a collodion is kept the less tough, or more rotten, it becomes, it is not desirable to make too large a quantity at a time.

The strength of the silver nitrate bath should not exceed 30 gr. to the oz. The developer, too, must be somewhat weak, consisting of 12 gr. iron protosulphate to the oz. of water, together with 1 dr. acetic acid and a few drops of alcohol, although the latter may be omitted if the developer flows smoothly.

The glass on which the picture is to be taken should have a coating of a solution of a wax or paraffin in ether, which must be rubbed off with a dry cloth. This leaves a very thin film that facilitates the removal of the collodion at a later stage. In exposing, according to the side of the negative that is turned toward the lens, so will the subsequent transparency be reversed or not; and it need scarcely here be said that the image, when finally placed upon the wood block, must be reversed, so as to print direct after it is engraved.

It is impossible here to give data for exposing, as this must be determined by a few trials. It is better to employ a lens with a small stop, and give a liberal exposure, having the negative directed either to a uniformly lighted portion of sky or backed at some little distance by a white card inclined backward. When developed, the lights must be absolutely transparent, and there must not be a trace of fog observable on the picture; nay more, the whole picture must be so thin and transparent as to permit the details of the shadows to be plainly seen when the plate is laid face down upon a sheet of paper. After fixing with cyanide and washing, tone by the application of a solution of platinum chloride, 1 gr. to 8 oz., or of a strength sufficient to penetrate throughout the thickness to the image in about a minute. It is recommended to add tartaric acid to the platinum solution, in the proportion of 5 gr. for each gr. of the metallic salt. When toned, the transparency, without being allowed to become dry, must be placed in a bath of diluted sulphuric acid, 1 oz. acid to a pint of water. This serves to detach the film from the glass.

But previous to the operation just described, the wood block must have been prepared. Place in a porcelain vessel 80 gr. Nelson's gelatine, or that of any other good maker, and cover it with cold water. Allow it to stand for 2–3 hours to absorb as much as it can; then drain off the superfluous water, and add 10 oz. warm water. If this does not cause the gelatine to dissolve, place the vessel near the fire, and it will speedily liquefy. Having rubbed up 30 gr. zinc oxide in a mortar with a little water, add it to the gelatine, and filter through linen into a wide-mouthed glass bottle. A few drops of carbolic acid will prevent decomposition, if it is to be kept any considerable time. Next apply to the surface of the wood a paste

made of zinc oxide and water, and rubbed by the palm of the hand, and then apply the gelatine by means of a broad camel-hair brush. This must be allowed to dry spontaneously.

Returning to the collodion picture in the acidulated water, it occasionally requires a little time, although sometimes only 1–2 minutes, to ensure the film becoming quite detached from the glass. When this is the case, a sheet of stiff waxed or paraffined paper is introduced, and the film is lifted out of the water by its agency. An easy way of doing this is to operate in a deep wooden dish having a plugged hole in the bottom. Lay the sheet gently down upon the collodion film, still *in situ* on the glass plate, although not now adhering to it; then, by withdrawing the plug, let the water run off, thus enabling the glass plate with the collodion film and the paper to be removed without disturbance.

The surface of the wood having been made wet by drawing a broad camel-hair brush dipped in cold water over it, the paper, to which the film now adheres in preference to the glass, is gently lifted up from the latter, and superimposed on the wood block, collodion side down. A sheet of blotting-paper is placed upon it, and over that a piece of rubber cloth, and moderately smart friction or pressure is applied to ensure the attachment of the collodion to the gelatined surface of the wood. By means of a penknife the margin of the paper is then raised, and the sheet lifted from the block, to which the film now adheres. This adhesion is rendered more firm by placing the block for a few minutes in a warm place, sufficient to impart tackiness to the still wet gelatine by which it was sized. To prevent the wood from warping, at this stage the back of the block should be sponged with water. Some operators effect the required adhesion by holding the surface of the block to the fire for a few seconds. But care must be taken not to let the collodion become dry.

The next operation consists in removing the collodion and leaving the image remaining on the wood. This is expeditiously effected by pouring over the surface first a little alcohol, following this by ether. If a good quality of soluble cotton has been employed, the collodion quickly dissolves by the method described. The wood is not effected by either alcohol or ether. When dry, the block is ready for being placed in the hands of the engraver, or in those of the artist to have the details supplemented by a few pencil touches, or for the removal of portions not desired to be engraved.

Although the film of gelatine upon the wood is so thin as not to clog the point of the graver, it may be rendered still more attenuated by increasing the proportion of water in the gelatine solution. (J. Traill Taylor.)

Flexible Plates.—Photographers, both amateur and professional, have long wanted some thoroughly efficient substitute for glass as a support for dry-plate films, and a few attempts have been made to supply the want with more or less of success. The following method has been recently proposed by Fickeissen and Becker, of Villingen, Baden. The plates or surfaces can be prepared from paper, cloth, or other suitable fabric or material, but by preference from white paper containing very little size and not much grain. This paper is first extended on a frame, or other arrangement, according to the size of the plate or surface which is desired. After it is dry, the surface is covered with a fine coat of copal varnish, for the purpose of rendering the fabric transparent; it is then dried, and after it is quite dry the surface is rendered smooth by the application of powdered pumice, if necessary, 2 or 3 times. The surface so prepared is then covered on one or both sides with a solution of gelatine or isinglass, and allowed to dry; it may be further treated with a preparation of ox-gall, from which the fatty matter has been extracted by alumina acetate, the resulting preparation being then passed through a filter, whereby a clear solution will be obtained with which the plate may be covered, so as

to secure the safe reception of the emulsion. Sheets prepared as above may be used with advantage in reproducing photographs from nature in lines or stipples for calico and other printing, as the stipples or lines can be printed first on the material before it is made transparent. Any photographic design or drawing can be put on the transparent surface in the usual way, and by using the film as a negative or positive in photographing from nature or from a drawing, half-tones will be produced in lines and stipples available for any kind of printing. As these sheets are waterproof, they can also be used as surfaces upon which to print all kinds of ornamental and useful work.

Silver Prints mounted on Glass; Medallions.—The prints to be treated should be printed darker than for ordinary mounting, care being taken not to tone them very much, or a cold blue or grey will be the result when finished. The glass plate intended for the reception of the print should be free from scratches or blisters, and must be most carefully polished with rouge, tripoli, or the usual polishing mixture. It is then placed on a water oven or heated over a gas-flame or other contrivance, until it can be comfortably borne on the back of the hand. Hot gelatine solution—1 part gelatine to 15 of water—should next be poured in a pool on the warm plate, and equally distributed over its surface by means of a glass rod; the prints, which are slightly smaller than the glass plate, are withdrawn from a weak solution of gelatine (1 part gelatine to 40 of water) and placed, albumenised side downwards, on the gelatinised glass plate, when it will be found that a good squeegeeing will remove the excess. When dry, the operation is complete. As a matter of fact, so largely have photographers availed themselves of this method of exhibiting their own productions, that it would be difficult to find a place of importance where the process is not employed. And here we may mention that we have noticed, in a few instances where show-cases have been exposed to considerable variations of temperature, including the full force of the sun's rays, portions of the photographs have dragged away from the glass support, and in a short time showed unmistakable signs of fading, while the parts still adhering appeared comparatively fresh. There is always a danger of the print coming up in patches unless the glass plate is thoroughly well polished, and as the instances we speak of were all pictures of large size, doubtless the defect was due to imperfect polishing.

A further development of this process is to be seen in the medallions, as they are called; that is to say, photographs surrounded with black varnish and a metal rim.

By abrading the back of the print with fine glass-paper, as recommended in the crystoleum process, it is possible, especially with landscapes, to produce a certain amount of coloured effects by means of liquid dyes in alcohol, and in many cases we have seen good results. When portraits, however, are so treated, they are seldom all that can be desired, the main difficulty being to get the proper depth of tint. The only difficulty likely to be encountered in the production of these pictures will be with the gelatine. Temperature, as in carbon printing, plays an important part: 65° F. (18° C.) will be found the most satisfactory temperature for the coating and drying room, and every precaution should be taken to obtain that result, or failures are sure to follow. Having regulated the temperature, the following articles will be required:—A flat tin dish for dissolving the gelatine, arranged over a Fletcher air-burner gas-stove, and a similar dish for soaking the prints in the melted and filtered gelatine; also a jug for pouring the solution over the glass plate, arranged over a fine jet of sufficient heat to prevent the solution cooling; a Wedgwood funnel, into the neck of which is placed a piece of clean wet sponge, answers well for filtering; a glass rod for distributing the gelatine over the plate; a rubber squeegee, and a piece of American cloth to protect the print while squeegeeing; strips of wood 1 in. broad, of any length, 2 such strips

joined by cross-pieces forming racks for drying; padded blocks of the same size and shape as the medallions will be useful (the pad forms a cushion for the glass, while the raised surface allows of passing the burnishing tool quickly round when fastening down the rim); a stock of prints trimmed to the desired size and shape. In the majority of cases, 1–2 in. margin of clear glass is allowed, this margin being afterwards filled in with Bates' dead-black varnish, as described below. A stock of oval dome-top or other shape glasses; suitable backs for these shapes fitted with rings; metal rims to fit; Bates' dead-black varnish; Young's patent size, as sold at the oil-man's, completes the list.

Melting the gelatine:—Cover the bottom of the tin with size broken up into small pieces. Enough cold water is poured over to cover the pieces, when the temperature is raised to nearly 200° F. (93° C.), to ensure perfect solution. When melted, a portion of the solution is passed through the sponge into the second dish for soaking the prints, and the remaining portion is passed into the jug, and kept hot by the means above stated. A well-polished plate is heated to 100° F. (38° C.), placed on a level slab, and covered with a pool of hot size. Should the solution prove refractory, the glass rod will assist spreading. Quickly transfer a soaked print from the second dish of hot size to its position, face down, on the plate, and roughly squeegee; remove the excess with a sponge, and again apply the squeegee, this time interposing a piece of American cloth to protect the print. If no air-bells are seen when examined from the front, the plate is placed on the rack to dry, paper side uppermost, which in a good current of dry air will occupy a couple of hours. When dry, the back should receive a second coating in like manner, another 2 hours being required before the next operation. When the second coating is quite dry, a brush well charged with Bates' black is passed round the margin, completely coating the bare glass, care being exercised not to allow the varnish to overlap the photograph more than is really necessary; 30 minutes' drying will remove the last traces of tackiness, and no more remains to be done than to fit the back, adjust the metal rim, and secure it down neatly with a burnishing tool to the padded block.

Landscapes and figure studies, nicely vignetted to the edge of the plate, are very effective when mounted as described above, on oval glass plates, in which case the use of black varnish is, of course, dispensed with. (*Photo. News.*)

Vitrified Photographs.—At the works of the Ceramic Stained Glass and Vitrified Stained Glass Company at Chingford the dusting-on process is adopted. Sensitive plates are prepared, upon which the enamel colour is dusted; and it does not follow by any means that the glass or porcelain first coated with the sensitive mixture is that upon which the enamel is finally vitrified, as it is quite easy to transfer the dust image to a new glass or tile. If, however, the image is to be transferred, the glass should be collodionised and allowed to dry before the application of the sensitive mixture. The exact composition of the sensitive preparation used is a secret, but the mixture recommended for this purpose by Dr. Liesegang, which answers very well, is as follows:—

Water	100 parts
Moist sugar	10 ,,
Gum arabic	10 ,,
Ammonium bichromate	4 ,,

The glass, very carefully cleaned (and collodionised if the image is to be transferred), is now placed on a levelling stand, flooded with the sensitive mixture, and after the composition has been allowed to remain on for a few seconds, the excess is drained off, the plate being now dried in an inclined position. The drying cupboard is contained in the "dark"—or rather, yellow-lighted—portion of the building; but no doors separate the dark room from the rest, the entry of white light being prevented by hangings of baize arranged on the baffle-plate principle, so that one can walk in or out of the yellow room with-

out touching or disturbing the hangings. The warm cupboard stands on a tin water vessel, scarcely 2 in. deep, and about 2 ft. wide by 5 ft. long, the whole being closed, excepting that a pipe is provided, by which any vapour may escape. The wooden bottom of the drying box stands directly upon the top of the hot-plate or water-bath, and the front of the box is merely closed by means of a curtain. As the plates are coated, they are reared up on edge in the cupboard, and allowed to remain until quite dry, when they are ready for exposure in the printing frame. Much depends upon care in drying, and many fail in the working of the dusting-on process through drying the plates at too high a temperature; indeed warm weather often demands no artificial heat at all. To the hand, the interior of the drying box seems only a trifle warmer than the external air, and one may perhaps estimate it at about 85° F. (29½° C.). The large flat water-bath or hot-plate upon which the cupboard stands is kept sufficiently warm by one paraffin heater with a 4-in. wick, and turned down very low. The special advantage of the hot-water plate is that it ensures a uniform heat all through the bath; very little over-heating is fatal, as it bakes the mixture, and renders it incapable of again absorbing moisture.

The exposure is made under a transparent positive, and the greatest care is exercised to see that printing frames and transparencies are perfectly dry; indeed, it is generally considered advisable even to slightly warm them before use. An apparatus provided with a heating arrangement consisting of a battery of paraffin lamps, is where the printing frames are placed during damp weather; without some such arrangement for keeping them perfectly dry, the work would be uncertain. The exposure required is not a very prolonged one, a single minute in bright sunshine being often sufficient, while in dull daylight ½ hour or more may be required. No actinometer is used, it being easy for one who is constantly at the work to judge the exposures with sufficient accuracy. The effect of exposure to light is to destroy the power of absorbing moisture which the sugar and gum ordinarily possess, consequently when the plate is withdrawn from the printing frame and exposed to damp air for a few minutes, those portions which have been protected from the action of the light will hold the vitrifiable pigment which is now dusted over the plate, while the most exposed parts refuse to take up any pigment, because they do not become adhesive by the absorption of water. For dusting with the vitrifiable pigment —which is just such a powder colour as potters use in decorating their goods —the plate is laid in a tin dish, and the powder is dusted over with a broad camel-hair brush. If the image is very slow to appear, one may venture to breathe very cautiously on the plate, after which the enamel colour is again applied. A little consideration will show that in this process over-exposure results in a hard image, while fog or general tinting is a consequence of under-exposure. When a perfect picture, having all the gradations of the original, is obtained, the excess of pigment is brushed off, and the powder colour is fixed by flowing collodion over the plate. If the plate were now fired, the chromium compounds in the film would become vitrified, and would give a disagreeable green tint to the picture, so some means of ensuring their removal must be adopted.

One secret is the composition of the fluid in which the plates are soaked at this stage to remove the chromium; but Dr. Liesegang recommends soaking for ½ hour or so in a 2 per cent. solution of caustic potash. The chromium having been removed, and the plate dried, all is ready for the final operation in the furnace, if the vitrification is to take place on the original support; but if the film is to be transferred, the plate must be allowed to remain in very dilute acid (say 1 part nitric acid in 60-80 of water) until the film can be floated off, and placed in position on the glass or tile which is to be decorated. (*Photo. News.*)

Enamel Photographs.—A sheet of any smooth-surfaced glass (plate is best) is cleaned by any of the usual photographic methods; now rub over the plate a solution of alcohol containing about 5 drops nitric acid to the oz.; rub over the glass, and polish with a dry piece of Canton flannel; finally dust a little soapstone or French chalk from a small muslin-covered box containing the chalk; brush it off lightly with a clean piece of Canton flannel; be careful not to rub hard, as in that case the chalk would deaden the polish of the glass plate. This done, the glass is coated with plain collodion, 5 gr. cotton to the oz. of equal parts alcohol and ether. The plate is allowed to dry, and can be kept in this state any reasonable length of time. When dry, lay the plate upon some level place, and cover with a solution of plain gelatine about the consistency of cream, at a temperature of 90°–100° F. (32°–38° C.); allow the plate to lie flat until the gelatine sets, which will depend on the temperature of the room.

When dry, stand the plate (or plates) up to dry, and store them away; in this state they will keep indefinitely, and it is well to keep a stock on hand in this condition, as pictures can be mounted in a few moments.

To mount the picture, lay one or more plates upon some level place over the sink, so that the water to be used will have free escape to the waste pipe. Cover the plates fully with water, allowing as much to remain on the surface as possible; lift the pictures from the water they have been washed in, and lay them face down upon the prepared surface of the plate, filling it with as many prints as it will hold, arranging them according to their sizes; pay no attention whatever to the bubbles. Have a piece of thin rubber cloth and a squeegee; lay the rubber cloth over the plates, and with the squeegee press the pictures into contact with the glass, at the same time take out all air-bells by passing it back and forth over the plate. This done, run around the edge of the plate with a knife to cut off the gelatine and collodion, ½ in.; this is to allow the paper that is mounted on the back of the picture to adhere to the glass, which will thus bind the whole thing down until liberated by being cut inside this safety edge, otherwise the pictures would be apt to leave the glass before they are thoroughly dry, and thereby lose the brilliancy they would have if properly dried. After the pictures have got surface dry, give them a coat of thin gelatine, and cover them with a sheet of Manilla paper or any common paper, same size as the plate; now mount them with cardboard, known as printers' cardboard, because it is cheap and answers every purpose; finally cover the whole with an enamel sheet of paper of any tint desired, thus having an enamelled mount, when the picture is finished, as well as an enamelled photograph. After they are thoroughly dry, cut inside the safety edge, when the prints will come off with all the beautiful finish possible. The prints may now be stamped out with a round or square cornered die, or cut with a knife any desired shape; the edges may be bevelled and bronzed with a little gum-arabic and bronze applied with a camel-hair brush. (T. Inglis.)

Toning.—The art of toning is one which the amateur is apt to give too little attention to. Excellence in all the manipulations connected with the production of a negative, even including the making of the plates, and, indeed, excellence in every operation in the production of the finished picture up to that of toning, is common enough with amateurs. Excellence in toning is not so common. "Nothing is easier than to tone, nothing more difficult than to tone well," had been said; and there certainly is much truth in the saying. By excellence in toning we mean not only the ability to get a good colour with pure whites and transparent shadows, but also the power of getting any tone we require, of course confining our requirements to the possibilities of the matter. The variation produced by varying the toning bath and manner of toning is not confined to the colour obtained only, but shows itself in the

general quality of the print. You may have 2 prints taken from the same negative, and printed on portions of the same sheet of paper. The colour of the tone is not very different: it would be described as a warmish brown in each case. The difference in the general appearance is, however, great. The one is a clear, brilliant, and pleasing picture; the other, though it would scarcely be placed in the category of "mealy prints," is a flat, dirty, uninteresting-looking object. Now these 2 prints were toned in the same bath. They show how much depends on the small details of the process merely.

Beginning at the beginning, and taking in succession the various small matters which we have found worthy of attention if we desire to get a pleasing colour in our prints, we may take first of all the quality of the negative. As is generally known, the influence of this on the tone of the finished print is very great, but wherein this influence exists is apparently not quite fully understood. It is commonly said that a negative showing strong contrast will give a print which may be toned to a rich colour; but something more than this appears to be required. A negative with a contrast ever so great, if under-exposed, will not give a print readily toned to a pleasing colour. It is difficult to see why it should be so, but it is evident that the gradation of density of the negative is a great factor in the colour of silver prints obtainable from it. We will get, as a rule, a better tone from a negative which might be described as "somewhat delicate but full of detail" than from the densest possible negative which is even a little under-exposed.

We do not intend at present to enter into the question of the manufacture or sensitising of the paper, because, as a rule, amateurs use ready-sensitised paper. We, therefore, pass on to the actual printing. It is an opinion commonly held that the longer, within limits, a print remains exposed in the frame—that is to say, the poorer the light — at the time of printing, the better will be the tone. It is certainly the case that prints done in very brilliant sunshine, and, therefore, in a very short space of time, do not, as a rule, tone as well as those which have taken longer to print; but we have not found the difference to be very great.

The manner of keeping the paper both before and after printing is a matter of importance, as we all know ready-sensitised paper turns brown from being kept. It may, however, turn in two totally different ways. It sometimes turns of the same colour that it would were it slightly exposed to light. This appears to be the effect of the action of pure air and damp, and does no harm so far as the colour obtainable by toning is concerned. There is, however, a very different discoloration which results from exposure to the smoky, impure air of London, and probably comes about from the action of sulphur in some form. It is distinguished by a metallic lustre; the effect of this is disastrous on the tone of the print. Nothing but the most sickly colour is possible from paper which has turned its colour in the manner described. From this we gather the importance of keeping ready-sensitised paper in a place where the air is as pure as possible.

It is probable that the stage at which the most can be done to make or mar the tone of a print is that of the washing which is performed previous to the toning. If, for example, the prints be placed in the water in masses, and be allowed to adhere one to another for any length of time—or, in fact, if they be allowed to remain for any length of time in water which contains a considerable quantity of the free silver nitrate which washes out of them—ruination of the tone will be the result.

It appears to be of importance to get the first silver which is washed from the prints away from them as quickly as possible, and for this reason they should be placed first in a large vessel, and should be removed from this first washing vessel to a second after a very short immersion. The next point of importance is the extent to which the

washing should be carried. Here let us say that we are in favour of eliminating all, or very nearly all, the free silver nitrate by very thorough washing, followed by the application of a solution of common salt to convert what silver nitrate is left into chloride.

There appear to us to be various objections to the presence of free silver nitrate in the prints at the time of toning. For one thing, it is a very uncertain factor in the process. We never can tell how much we have washed away and how much we have left, and consequently there is uncertainty introduced in the result. When we wash out all the silver nitrate the uncertainty ceases; and not only that, we find that if, as certainly is the case, the toning takes much longer, or requires a much stronger solution of gold, the result is infinitely better than that got when silver nitrate is present. A further great advantage lies in the fact that prints toned without the presence of silver nitrate do not change their colour in the fixing bath; those toned in its presence do. We have, therefore, if we have thoroughly washed our prints, merely to wait for the colour we require, and then to remove the print from the toning bath. It certainly is the fact that with most ready-sensitised paper it is impossible to get a very good purple tone. We can, however, get a very warm brown.

Concerning the use of the salt solution, it would appear from mere theoretical reasoning that there can be no need for any washing at all before using it. It is difficult to see why it should be objectionable to get rid of the whole of the silver nitrate by converting it into chloride, but the fact remains the same that we do not get a good result if we place the prints direct from the printing frame into the salt water. It is also a fact that if the salt solution be beyond a certain strength, the prints refuse to tone at all. Considering these two facts, it becomes merely a matter of experiment to determine how to use the salt. We have proceeded as follows with good results.

We wash the prints till the greater part of the muddiness of the washing water has disappeared: this means 3 or 4 changes of water. We then dip for 10 minutes in water which contains ½ oz. common salt to each gallon. After that we wash in other 3 changes of water, and proceed to tone. The only difference in the manipulation in toning the 2 prints mentioned above was that the first was allowed to soak for some time in its first washing water, and was then but imperfectly washed. The second was at first rinsed briskly in running water, and was afterwards treated with the salt solution as described. It took 5–6 times as long to tone as the first. For the sake of completeness, we give the formula we were using, although we believe the difference in result produced by different toning formulæ is vastly less than the difference which may be brought about by varying mere details of manipulation:—

Gold chloride	1 gr.
Borax	60 gr.
Water	12 oz.

(*Photo. News.*)

Outdoor Photography.—It frequently happens that the amateur in outdoor photography requires a plate which will retain its sensitiveness for a few hours, such as the photographing of objects within easy reach of his home. This can be accomplished in a most satisfactory way, without resort to dry-plates or tent, by proceeding in the usual manner as regards coating and sensitising the plate, and, after thoroughly washing it, applying the following preservative solution:—

Glycerine	12 dr.
Albumen	2 oz.
Water	4 oz.
Ammonia	2 drops

No special collodion is required, and the formula is easily made up and applied. As to developing the plate, a 4-gr. solution of pyrogallic acid will be found sufficient; and when all the details are well out, intensification with pyrogallic acid and silver will secure a good nega-

tive. Plates so prepared will keep moist for *at least* 4 hours in moderately warm weather.

In case the subject to be photographed is within a mile of dark room, and provided the weather is cool, the ordinary wet plate, without any preservative, will answer, as, by attending to the following hints, the plate will keep moist for at least 20 minutes. After taking the plate from the bath, place it in the dark slide, *in a horizontal position, and carry it in that position to the camera*, and, after exposure, bring it back to the dark room *in the same position* and develop *at once*. A small piece of blotting-paper must be placed in each corner of the dark slide, to prevent any of the silver solution flowing over the plate, and a piece of damp blotting-paper should be placed on the back of the plate, to prevent evaporation as much as possible. Give a little longer exposure than you would under ordinary circumstances, and use a little more alcohol in the developer.

Negative Bath.—The following negative bath will be found excellent, reducing the expense by one-half, and giving negatives of a first-class description, with an entire absence of "pinholes":—

Silver nitrate	1 oz.
Barytes nitrate	½ dr.
Potassium iodide	8 gr.
Water	12 oz.
Nitric acid ..	Enough to make slightly acid.

The developer best suited to the above is the following:—

Iron protosulphate	40 gr.
Acetic acid	½ dr.
Water	2 oz.
Alcohol	(quant. suff.)

Intensify with silver.

Varnishes.—(1) A solution of shellac methylated spirit forms the basis of varnish, and a simple varnish so made will answer for all rough work; but where delicate results are wanted, it must be paler in colour, and for this purpose use "bleached shellac." Bleached shellac dissolved in spirit also makes an excellent varnish; but it is not nearly so hard and tenacious as that from the orange shellac. A good strong coating of it is readily scratched by the finger-nail—a *contretemps* so likely to occur in printing that such a varnish cannot be recommended. White shellac is made by dissolving ordinary shellac in caustic alkali, and then treating the solution with chlorine, which at one and the same time decolorises and precipitates it. This process, though it produces a pale resin of great value for many economical purposes, causes the resin to lose many of those properties that specially fit orange lac for use in photographic varnish. One of the peculiarities of white lac varnish is the frequency with which it dries into a multitude of fine ridges, which no rocking of the plate to and fro during draining and drying will prevent. But for paleness of colour in the coating obtained from it nothing can be better; and in a mixture of the two resins — that is, the bleached and the unbleached—the objectionable qualities of either seem either covered or greatly minimised This mixture in suitable proportions constitutes the chief part of the varnish recommended.

Experimenters with "bleached," or, as it is often called, "white lac," must know that unless it be properly stored it practically loses its solubility in spirit of wine; and many cases of failure in varnish-making are caused through the purchaser being supplied with a sample that had become insoluble. Of course this would not be likely to occur in a place where the lac was in great demand; but many of our readers live in places where photographic—indeed, any rare—chemicals are most difficult to get, and when obtainable are not always in good condition. However, in the case of white lac, where the experimenter is ignorant of the appearance it should present, he can easily test a small quantity if he have any doubt in the matter. It should be crushed or pounded into small pieces before adding to the spirit, as even in the best samples a large proportion entirely insoluble always

exists, and a clear solution must not be expected. Its solubility or the reverse is soon discovered by noticing whether the small particles begin to disintegrate, as it were, or retain their sharp outlines.

A good indication of insolubility is the outer layer of the round pieces or sticks turning semi-transparent. The plan usually adopted to prevent this change taking place is to keep the bleached lac in the dark and covered with water, when, if it remain so covered, it will retain its solubility in spirit for a lengthened period.

The third and last ingredient in this varnish is sandarac. It is well known by varnish-makers that, when resins are mixed and "blended," the character of the solution or varnish is not by any means of necessity an average of the characters of the resins taken separately, and such is the case with sandarac. This resin taken by itself gives a varnish that is quite useless from its brittleness, but when added to a shellac varnish it confers a portion of its own quality of brightness of surface, which it possesses in a high degree, but does not, in moderate quantity, tend to make it "rotten."

The formula for a varnish devised on the principles above enunciated is as follows:—

Palest orange shellac ..	2¾ oz.
Bleached lac	5½ oz.
Sandarac	½ oz.
Methylated spirit	1 qt.

Bruise the bleached lac till reduced to small pieces. Powder the sandarac, and then add the whole to the spirit, putting in a few small pieces of glass to prevent the shellac caking at the bottom of the jar; stir or well shake the whole from time to time, till it is evident that solution is complete. All that is then necessary is to set aside to clear, pour off the clear, supernatant fluid, and filter the rest. It is best to allow a month or two for subsidence, for the insoluble part occupies so large a space that much waste through evaporation, &c., is caused if an unnecessarily large quantity be passed through the filter.

(2) Quick-drying Varnish for Ferrotypes.—A very good and hard varnish used for negatives which have to stand far more handling than a ferrotype is composed of equal parts of white hard spirit varnish and alcohol. Warm the plate, and apply as collodion, pouring off the superfluous quantity; slightly warm again, and on cooling, which takes place in a minute or two, a fine hard coat of varnish will be found—so hard that it can scarcely be scratched with the finger-nail. The process used for ferrotypes is very similar to that for glass positives, with the exception that a special kind of collodion should be used so as to produce a thin deposit with considerable detail.

(3) Elastic Dammar Varnish. — An elastic flexible varnish for paper, which may be applied without previously sizing the article, is prepared as follows: Crush transparent and clear pieces of dammar into small grains; introduce a convenient quantity—say 40 gr.—into a flask, pour on it about 6 oz. acetone, and expose the whole to a moderate temperature for about 2 weeks, frequently shaking. At the end of this time, pour off the clear saturated solution of dammar in acetone, and add, to every 4 parts varnish, 3 of rather dense collodion; the 2 solutions are mixed by agitation, the resulting liquid is allowed to settle, and preserved in well-closed phials. This varnish is applied by means of a soft beaver-hair pencil, in vertical lines. At the first application, it will appear as if the surface of the paper were covered with a thin white skin. As soon, however, as the varnish has become dry, it presents a clear shining surface. It should be applied in 2 or 3 layers. This varnish retains its gloss under all conditions of weather, and remains elastic; the latter quality adapts it especially to topographical crayon drawings and maps, as well as to photographs. (*Pharm. Centralhalle.*)

(4) For Prints.—Heat a piece of glass, and rub a little wax over it with a bit of cotton-wool. Pour water over the plate, and press the picture down upon it with a piece of filtering paper. When

dry, the picture is removed, and will be found to possess a brilliant surface.

(5) For Gelatine Negatives.—One of the minor difficulties in connection with the working of gelatine plates is that of varnishing. In the abstract it should, no doubt, be the simplest of all operations; and with collodion, given a moderate amount of care, such was the case. But with gelatine, for various reasons, the apparently easy process of giving the final protective coating to the otherwise finished negative is found to be, to say the least of it, a somewhat unsatisfactory one; and many operators refuse to varnish their negatives at all, prefering to risk the dangers of printing from bare gelatine films as being the safer plan.

The difficulty arises partly from the physical and partly from the chemical properties of the gelatine. Its powerful affinity for water and its great absorptive powers, and consequent swelling under the action of moisture, render the gelatine film anything but a suitable companion, at close acquaintance, with the hard, brittle, and inflexible layer of resinous matter which is laid upon it, as its protector. This latter, no matter of what materials it may be composed, has hitherto proved wholly inadequate to perform the *rôle* expected of it, and, though supposedly waterproof, appears only to intensify the danger which moisture may threaten to the film of a gelatine negative. A single drop of water on a varnished gelatine negative will, after a very brief contact, leave a mark which, if not indelible, requires the entire removal of the varnish before it can be obliterated, penetrating, as it does, through the film of varnish to the gelatine underneath, and causing the latter to expand and crack the inflexible layer of resin above it.

If the moisture be presented in the form of silver solution, or if silver from damp sensitised paper gain access to the film, the result, though less immediately visible, is far more fatal. Combination takes place between the silver and the gelatine, and brown stains result, which, in the majority of cases, it is quite impossible to remove. Dissolving off the varnish is useless, for the action of the silver will be found to have passed right through that and to have attacked the under layer of gelatine, forming a compound which is amenable only to those reagents which attack the developed image itself.

It appears useless to hope for any way out of these difficulties by merely altering the constituents of the varnish. The fact appears to be that none of the resins usually employed (not even shellac) are really impervious to moisture; and, this being the case, the absorptive powers of the gelatine and its consequent swelling render it hopeless to expect to do more than ameliorate matters. A preliminary coating of collodion has been recommended, and certainly is a great improvement upon varnish alone; but, as applied in the ordinary way, a still greater improvement is to employ the *collodion* alone, and apply the varnish to some other purpose. The intervention of the collodion greatly retards the absorption of moisture by the gelatine film, though it does not arrest it entirely, consequently the ultimate effect is the same as with varnish alone; but, if collodion by itself be used, it is sufficiently elastic to accommodate itself to the expansion of the gelatine without splitting or cracking, and when the plate is dried, no trace of any injury remains.

The hardness of a collodionised gelatine film is very surprising to those who are not accustomed to this mode of "varnishing," but something more is wanted. The author tried many different kinds of varnish, some of them specially prepared for "dry-plate" work; but whether with or without the preliminary film of collodion, he found nothing that would absolutely resist moisture. He, however, succeeded in attaining with some trouble a degree of protection which practically answers for all the dangers that any ordinary negative is likely to be exposed to, though it may be a question as to whether it is worth while to adopt it in all cases.

His experience with *all* varnishes, as supplied commercially, is that they are

too thick for gelatine films, though they may answer for collodion. The latter, it must be remembered, is spongy and porous, and absorbs some of the alcoholic varnish; while gelatine, on the contrary, rejects it entirely. Consequently, varnish of ordinary thickness flows badly on a gelatine plate, dries slowly, and is a very long time before it loses its "tackiness." He therefore dilutes the varnish with *at least* an equal volume of methylated alcohol, and filters carefully through filter-paper. The negative, after drying, is heated and polished with an old silk handkerchief and a little powdered talc; it is then collodionised, dried, and varnished. After the latter operation, strong heat is applied for at least 10 minutes; the plate is then allowed to cool, and is again polished with talc. If extra protection be required, the operations of collodionising and varnishing are repeated, the result being a surface which is far harder and more impervious to moisture than if a single coating of collodion and *thick* varnish had been used.

A good, cheap varnish for this purpose consists of hard white spirit varnish diluted with 4–5 times its volume of methylated alcohol. The collodion may be ordinary "enamel" collodion, diluted with an equal quantity of a mixture of ether and alcohol. (H. Y. E. Cotesworth.)

(6) Water Varnish.—Take ¼ lb. of shellac (in thin flakes), and 1 pint water; place them in a tin saucepan or other suitable vessel on the fire or over a gas stove, and raise to boiling point. When this is reached, add a few drops of a hot saturated solution of borax, stirring vigorously with a glass rod or clean stick until this shellac is all dissolved, which will be in a few seconds. Do not use too much borax, but add slowly, and stop short of complete solution rather than the other way. After this, the solution is filtered through charcoal, and the water varnish is ready for use.

For wet collodion negatives it is invaluable, as its use entirely does away with split films; and when only 1 or 2 prints are required, the negative need not be varnished with spirit varnish. All that is required, after the negative is washed, is to flood it with the water varnish, and stand up to dry; when dry, the negative is ready for the printer so far as the surface is concerned. A film so protected stands a great deal of rough usage, and is not very easy to scratch, while for retouching the surface it is superb. For wet collodion negatives, the advantages are certain immunity from split films, and saving of time, trouble, and expense of spirit varnish, fire, &c., and risk of cracking the plate from the action of heat.

For gelatine negatives, water varnish is applied directly after they are washed, and, when dry, the retouching is performed, and spirit varnish is applied in the usual way, when there will be little danger of the films being silver stained, no matter how long they are in use.

A gelatine negative, covered with water varnish and dried, was placed upon a shelf, and a cotton-wool plug out of a silver funnel was laid upon the film. At the end of 3 days no sign of a silver stain was visible, and this without any spirit varnish over it. This water varnish will be found far superior to a film of plain collodion, besides being easier and simpler of application.

One important point in favour of a water varnish is the fact that it can be applied to the film when wet, and therefore with all its pores open; while that part of the varnish that does not sink into the film, but remains upon the surface, will give a gripe or hold for the subsequent film of spirit varnish, affording a promise of security more in accord with the known permanence of a well-varnished collodion negative. (W. T. Wilkinson.)

(7) The following recipe for a retouching varnish is given in the *St. Louis Practical Photographer* by A. St. Clair:—Best orange shellac, 2 oz.; ammonia carbonate (in crystals), 4 oz.; soft water, 32 oz. Raise the water to nearly boiling point, then add the ammonia, and, when that is dissolved, the lac; stir well until the whole of the lac is dissolved; allow it to cool, and filter.

Apply it to the negative by pouring on and off a few times, and dry thoroughly.

(8) Lacquer.—Amber, 1 part; copal, 1; benzole, 2; spirit of wine, 15.

(9) Lacquer.—Amber, 2 parts; copal, 2; mastic, 1; petroleum naphtha, 10; spirit of wine, 20.

The raw materials for preparing lacquers for photographers must be chosen with the utmost care, as it is absolutely necessary that these lacquers should be entirely colourless.

(10) Alcohol, 5 oz.; bleached shellac, 6 dr.; camphor, 1 scr.; essence of bergamot, 10 drops.

(11) It was not long after the general adoption of the gelatine process that it was discovered that the varnish hitherto used for collodion negatives was not a sufficient protection in the case of gelatine negatives when large numbers were required to be printed. Minute spots first made their appearance, and these rapidly multiplied and increased in size until the negative became useless. Many methods of treatment were suggested and carefully tested as a protection against the caustic action of the silver salt on the film of gelatine; but suffice it to say that none was found to equal in efficacy a coating of collodion followed by another of spirit varnish; and, judging from subsequent experience, these substances, if properly applied, seem to be a perfect remedy for the evil.

A suitable collodion is made by dissolving a tough soluble pyroxyline, such as is used for surgical collodion, to the strength of 6 gr. to the oz. in equal parts of methylated alcohol and methylated ether ·720. It is allowed to settle for some days; and the clear collodion may then be applied to the negative in the usual way. It should not, however, be drained off too closely, but should be allowed to flow back evenly over the surface, and the plate then placed on a level support until set. When dry, a thick impervious coating results, which is rendered hard and proof against ordinary risk of mechanical injury by the application of a lacquer prepared as follows:—

To ½ lb. "button lac" and 2 oz. sandarac placed in a flask, add ½ gal. methylated alcohol, and shake up occasionally during a week, by which time the soluble portion will be taken up; but do not use artificial heat to dissolve the sediment, as it is better filtered out. Button lac, although apparently browner than shellac, is recommended in preference, as it really gives a lighter coloured solution; but even seed-lac may be used if the precaution be taken after filtration of boiling the clear but dark-coloured varnish for 10 minutes in a flask on a water bath with 4 oz. freshly prepared animal charcoal, which treatment, followed by a second filtration, effectually removes the orange dye which would otherwise tend to retard the printing. The collodionised negative is warmed as usual before and after lacquering. Many negatives thus treated have been in contact with sensitised paper for several months at a time, and exposed in all weathers during the last 3 years without any apparent detriment; so it is hoped that this record may not be without some practical value. (W. Bedford.)

(12) Krüger considers that all acid and gummy constituents should be removed from resin by treating it with soda before it is dissolved in alcohol to form photographic varnish.

(13) If your pictures are otherwise satisfactory, you need only proceed as follows, to ensure their keeping for printing:—Prepare a weak solution of gum, say 1 oz. gum to 4 oz. water. When your plate is developed, fixed, and washed, and while still wet, pour over it some of the above gum water, and cover the plate with it as with a varnish. Rear up on edge to dry spontaneously. This forms a perfectly protective covering, which never sticks to the albumenised paper, no matter how hot the sun may be.

(14) Colourless Negative Varnish.—Dammar, 2 parts; mastic, 1; sandarac, 0·5; chloroform, 20; tar-varnish oil, 20.

For preparing this varnish, the finely-powdered resins are tied in a small linen bag and suspended from the lower part of the cork in a bottle containing the

corresponding quantity of fluids. The solution will be accomplished in a short time if the bottle is put in a moderately warm place. After the resins have been dissolved, the clear varnish is poured off from the uncommonly small quantity of sediment. The process of lacquering the plates with the varnish is very quickly accomplished, as the solvent shows great volatility.

(15) Sandarac	4 dr.
Spirit of wine	20 dr.
Chloroform	½ dr.
Oil of lavender ..	3 dr.

The filtered solution is spread out by pouring it over the glass plate, and dried by applying heat. The coating is perfectly colourless, and negatives coated with this varnish do not crack, even if they are stored away for a long time.

(16) Monkhoven's Retouching Varnish for Negatives.—Shellac is placed for 24 hours in a saturated solution of ammonia carbonate in water. The solution is then poured off, and replaced by an equal quantity of pure water; the fluid is boiled under constant stirring until a complete solution has taken place. The proportion between shellac and water should be as 1 : 8. This is poured twice in succession over the negative, which must be thoroughly dry. Retouching can be done more quickly and finer upon this coating than upon any other.

(17) Retouching Varnish.—

Shellac	1 oz.
Sandarac	6 oz.
Mastic	6 oz.
Ether	10 oz.

Then 10 oz. pure benzole are added to the mixture after the resins have dissolved in the ether.

(18) Hard Lacquer for Negatives.—

Sandarac	20 dr.
Venetian turpentine	2 dr.
Oil of lavender	2½ dr.
Ether	2½ dr.
Absolute alcohol ..	50 dr.

(19) Lacquer.—

Mastic	2 dr.
Bleached shellac ..	10 dr.
Oil of turpentine ..	2 dr.
Spirit of wine ..	60 dr.

(20) Collodion, by itself—even the ordinary porous collodion employed in negative work—answers admirably. As a protection against damp, its effect is simply marvellous; for, should the moisture penetrate it and reach the gelatine film, it possesses sufficient elasticity to withstand the strain put upon it. It exhibits little tendency to absorb silver from the damp printing paper, and in the event of actual moisture being accidentally present when in contact with the paper there is no fear of adhesion. For portraiture, the film will bear working on with the pencil in retouching, though from its hardness and smooth surface it is usually desirable to use a "medium" to give a "tooth" which will take the pencil.

In preparing a special collodion for the purpose, select a good, tough—not necessarily "horny"—sample of pyroxyline, and use it of the strength of not more than 4 gr. to the oz., with 2 or 3 drops of castor oil. The best protective medium consists of a collodion made from celloidine, which gives a remarkably clear and structureless film, and may be used stronger than ordinary pyroxyline: 5 gr. celloidine and 2 drops of castor oil to each oz. of solvents will answer well. There is a slight advantage in employing a small excess of ether over alcohol in dissolving—say 9 parts ether to 7 of alcohol—both being as free from water as possible, and the negative very thoroughly dried before application.

(21) For Wet-plate Negatives.—

White hard varnish ..	½ pint
Methylated spirit (about)	1 pint

Try plate. If too thick, add more spirit. This will be found a capital varnish for retouching purposes.

(22) For Dry Plates.—

Red shellac varnish ..	½ pint
Methylated spirit (about)	1½ pints

Try a plate, and add or lessen spirit according to requirements.

(23) Fritz Luckardt's Retouching Varnish.—

Alcohol	300 parts
Sandarac	50 „
Camphor	5 „
Castor oil	10 „
Venetian turpentine ..	5 „

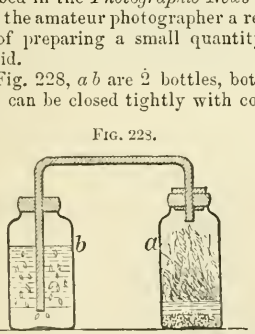
(24) Varnish to Imitate Ground Glass.—

Sandarac	18 parts
Mastic	4 „
Ether	200 „
Benzole ..	80 to 100 „

Sulphurous Acid, preparing.—Within a short period, sulphurous acid has become an important element in the preparation of an excellent pyro developer for gelatine plates; and as it is more or less unstable in its keeping qualities, some easy method of preparing a small quantity which shall have a uniform strength is desirable. A method recently described in the *Photographic News* will afford the amateur photographer a ready way of preparing a small quantity of the acid.

In Fig. 228, *a b* are 2 bottles, both of which can be closed tightly with corks.

FIG. 228.



A hole is made in the cork in the bottle *a*, a little smaller than the glass tube which connects *a* and *b*. It is filed out with a rat-tail file until it is large enough to admit the tube very tightly. The tube may be bent easily, by being heated over a common fish-tail gas-burner or over the top of the chimney of a kerosene lamp, so as to form 2 right angles, one end extending close to the bottom of the bottle *b* as shown.

Having fitted up the apparatus, about 2 oz. soda hyposulphite are placed in the bottle *a*, while the bottle *b* is about ¾ filled with water—distilled or melted ice water is to be preferred; some sulphuric acid—about 2 oz.—is now diluted with about twice its bulk of water, by first putting the water into a dish and pouring in the acid in a steady stream, stirring meanwhile. It is well to set the dish in a sink, to avoid any damage which might occur through the breaking of the dish by the heat produced; when cool, the solution is ready for use, and may be kept in a bottle.

The cork which serves to adapt the bent tube to the bottle *a* is now just removed for an instant, the other end remaining in the water in bottle *b*, and about 2–3 oz. of the dilute acid are poured in upon the hyposulphite, after which the cork is immediately replaced.

Sulphurous acid is now evolved by the action of the acid on the hypo, and as the gas is generated it is led as a series of bubbles through the water in the bottle *b* as shown. The air space above the water in bottle *b* soon becomes filled by displacement with sulphurous acid gas, which is a little over twice as heavy as air; so in order to expedite the complete saturation of the water, it is convenient to remove the bottle *a* with its tube from bottle *b*, and after having closed the latter by its cork or stopper, to agitate it thoroughly by turning the bottle upside down. As the sulphurous acid gas accumulated in the air space over the water is absorbed by the water, a partial vacuum is created, and when the stopper is eased an inrush of air may be noted. When, after passing fresh gas through the liquid for some minutes, no further inrush of air is noted on easing the stopper as before described, after agitating the bottle, it may be concluded that the water is thoroughly saturated with sulphurous acid, and is strong enough for immediate use. More gas can be gene-

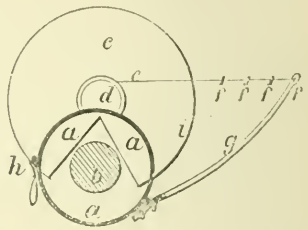
rated by adding more dilute sulphuric acid to the hypo until the latter is decomposed; then it should be thrown aside, and a fresh charge put in the bottle. On preparing the solution it is well to set the bottles on the outside ledge of the window, or in some other open situation where no inconvenience will result from the escape of the excess of sulphurous gas as it bubbles through the water.

The solution of sulphurous acid, if preserved at all, ought to be kept in small bottles, completely filled and perfectly closed; but as it is very easy to saturate a considerable quantity of water with sulphurous acid gas in a short time, there is but little inducement to use a solution which may possibly have become weakened by keeping.

Care should be taken not to add too much dilute acid to the hypo at a time, else excessive effervescence will occur, and the solution will froth over the top of the bottle.

Instantaneous Shutter.—Braun, of Angoulême, has presented to the Photo Society of France a new instantaneous shutter. The shutter is formed by a revolving metallic disc out of which a segment has been taken. This disc is placed in the centre of the diaphragms, in order to obtain the greatest rapidity combined with the least possible distance to travel. On the axis to which this circular disc is fixed is a small wheel, to which is attached a piece of string, and when the disc is turned round for the exposure the string is wound round the wheel. If the string be pulled, naturally the disc will revolve back to its former position so much the more quickly the more violently the string is pulled. Braun has replaced the hand by a steel spring attached to the drum of the lens (Fig. 229). By shortening or lengthening the string, more or less rapid exposures may be obtained. *a* is the lens; *b*, aperture of lens; *c*, metallic disc; *d*, wheel on the axis; *e*, cord or string; *f*, knots in string; *g*, steel spring; *h*, catch; *i*, socket for catch.

FIG. 229.



Arranging Drop-Shutters for a variety of Lenses.—It is often annoying, when wishing to use different lenses for instantaneous exposures, to find that each lens or tube requires a different drop-shutter to be fitted to it. By the following sketches and description an arrangement may be made that will answer the purpose. It is very simple, easy to construct, and practical.

FIG. 230.

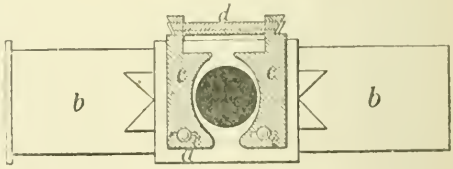
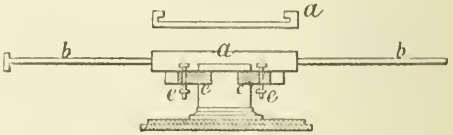


FIG. 231.



Two pieces of soft wood $\frac{3}{4}$ in. in thickness, shaped as shown in *c*, Fig. 230, are attached to the back of the main board *a*, by means of 2 thumbscrews *c*, which are put in from the front, having square

plates at this end, which must be fitted and sunk into the wood to present an even surface all over, against which the drop-board slides up and down (see Fig. 231, *c c*).

At the other end, a stout rubber band *d*, attached to the 2 projecting ends, exerts quite enough tension to hold the shutter firmly to the tube.

The clamps *c*, having each a slit of ½ in., can be readily moved up or down by loosening the thumbscrews.

The diagrams will show how and with what facility the shutter can be changed from one lens to another, larger or smaller. The hole in the board *a* should be somewhat larger than the largest tube to be used—that is, within a certain limit. For a larger class of lenses, a larger drop-shutter should be made.

An essential point to be observed in putting a shutter on to a tube, is to bring the front of the tube in almost close contact with the drop-board *b*—enough so not to impede the freedom of easy motion—before it is finally fastened. The inside edge of the opening of the drop-board, coming down over the lens first, must be bevelled off. The drop-board should be perfectly level. No fear of any light coming in need be apprehended, and it is not at all necessary that the tube should be encircled in wood to make it light-proof.

Where only 2 or 3 lenses are used, which are of nearly the same dimensions, the clamps can be screwed on the back of the shutter, stationary, and the slits and thumbscrews dispensed with.

All, except the board *a*, should be made of light wood. The drop-board *b* could be made of the same material as is used by some for slides in dry-plate holders—some kind of stiff and glazed cardboard, the inside painted black.

Because of lightness and probable slowness of motion, rubber bands could be employed, the same as for other drops.

Between two strips of cardboard, glued or tacked to the drop-board *b*, near the edges of the opening, insert a piece of cardboard, say 2 in. long, to move up and down stiffly over the upper or lower part of the opening. This makes a capital opening regulator, and will prove of great value.

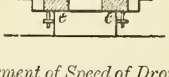
With regard to lessening the speed of the fall of the drop, it needs but a little resistance to show a marked difference. The pressure of a brass spring against the drop-board, so arranged that it can be regulated, is sufficient to make the fall measure ¼, ½, and 1 second. Longer exposures than one second can be better made by hand, using the cap of the lens.

In Fig. 230, *a* is a back view of board to go on tube; *b*, drop-board, with opening, running in grooves of *a* (see end view of *a*); *c*, clamps, made of ⅜-in. soft wood, having ½-in. long slits on one side; *d*, rubber band; *e*, thumbscrews passing through *a* and slits of *c* (see Fig. 231); a brass wire, on top of clamp only, prevents the rubber band from slipping off.

Fig. 231, side view of above, showing application to tube and *c*.

Fig. 232 shows rubber band.

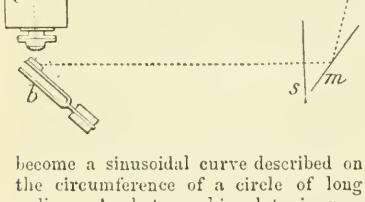
FIG. 232.



Measurement of Speed of Drop-Shutters.—The usual method adopted for this purpose depends on photographing a white clock-hand revolving rapidly in front of a black face. The chief difficulty in this case is to maintain a uniform rotation at high speed. To avoid this difficulty, and to determine the uniformity of exposure of any particular shutter under apparently like circumstances, the following method has been suggested. A tuning-fork *b*, Fig. 233, with a mirror attached to the side of one of the prongs, is placed in front of the camera lens. This mirror *m* is so arranged as to reflect into the camera *c* a horizontal beam of sunlight, which before reaching the fork has passed through a ½-in. hole in a screen *s* placed about 10 ft. distant. This produces on

the ground glass a minute brilliant point of light. If the fork be set vibrating, the point will become a short, fine, horizontal line; if the fork be rotated about its longitudinal axis, the line will

FIG. 233.



become a sinusoidal curve described on the circumference of a circle of long radius. A photographic plate is now inserted, and the drop-shutter attached. On releasing the latter, it will be found that a portion of the sinusoid has been photographed; and the precise exposure may be determined by counting the number of vibrations represented on the plate. The mirror employed should be somewhat larger than the lens to be measured, so as to cover its edges during the whole exposure. The mirror may be glued directly to the prong of the fork with strong carpenters' glue, after first scraping off a little of the silvering at the edges of the glass. The rate of the fork is then determined by comparison with a standard fork, by the method of beats. (W. H. Pickering.)

"*Instantaneous Shutter*" *for Timed Exposures.*—The necessity for carefully regulating the exposure according to the subject and the illumination is at once admitted in connection with ordinary photographic work. Whatever is true in counting by seconds, must also be true in counting by hundredths of a second; though there are many amateurs who are careful in the one case, and leave the other to luck which sometimes favours, but more often fails. And so instantaneous photography is to such operators uncertain and perplexing, except when it is confined to the same sort of views in fairly uniform weather.

It is, of course, as easy to calculate the exposure required for instantaneous as for other effects. The very beginner knows that if, for example, a view requires 2 seconds' exposure when using a certain stop and a known plate, that by changing the stop for one whose opening has an area 8 times as large, and the plate for one that is 3 times as rapid, the exposure then needed is $\frac{1}{12}$ second. Perhaps a drop-shutter will give an exposure near enough to that calculated to secure a good picture; but on another occasion, when $\frac{1}{25}$ second is the required exposure, the lens aperture must be reduced by a diaphragm, and the view be taken only half as instantaneously as it might have been, or else the shutter must be quickened by a rubber band or a spring, the wish being father to the thought that the exposure is thereby suitably corrected.

The fraction of a second required can be practically obtained by expensive shutters; but the writer has found that very considerable accuracy may be ensured by using a rotary shutter which was made for him in mahogany, by a carpenter, for 3*s*. About an hour's work afterwards, in adjusting it to the lens, blackening it, &c., and it was ready for use. The shutter described is in size suitable for a Dallmeyer's 5 by 4 rapid rectilinear. The shaded parts represent holes, or parts cut away.

The part that fits on to the hood of the lens is shown in Fig. 234, and consists of a piece *a*, $\frac{1}{8}$ in. thick, faced with a thin piece *b*, and strengthened at back by a round piece *c* to give a firm hold for the screw on which the rotary part turns. This last is shown in Fig. 235, and is a 5-in. disc of thin mahogany with a hole cut out as shown, and a cylindrical piece *e*, which strengthens the centre, and has a small screw at *f* projecting far enough to tie a thread to its head. The dotted space *g* shows the form of the regulator; it turns stiffly on *e*, and serves to reduce the aperture in *d*. The figures show the proportion that the aperture bears to the whole circumference; $\frac{1}{4}$ when fully open, and reduced by the regulator *g* to $\frac{1}{5}$, $\frac{1}{6}$, &c., to $\frac{1}{10}$ or less if desired. *h* is a piece of lead attached to the regulator,

and is just heavy enough to determine that when at rest this part shall be lowest, and the shutter so kept closed. The revolving piece turns as easily as

FIG. 234.

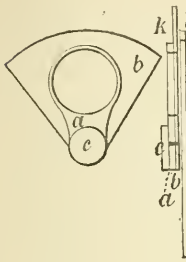
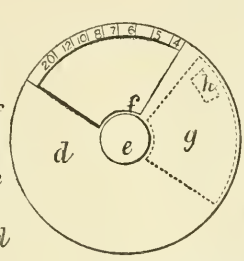


FIG. 235.



possible on a screw that is fixed tightly through *b* and *a* into the centre of *c*. A strip of cardboard fastened all along the edge of *b* as shown at *k* makes the apparatus practically light-tight when closed, in spite of a little irregularity in the surfaces of *d* and *b*. A piece of strong coarse thread or silk 12–18 in. long is tied to the screw *f*.

It is obvious that with such an apparatus, one revolution of the wheel with its aperture fully open will give an exposure of exactly $\frac{1}{4}$ of the period of revolution, provided that the motion is regular. By reducing the aperture, the exposure may be diminished to $\frac{1}{5}$ or any other proportion desired. The single revolution is obtained by the cord attached at *f*, by giving it one turn round the cylinder *e*, and then pulling it off as a clock cord is pulled by the weight off the drum it is coiled on.

It was at first thought that by using a weight, a more regular revolution would be obtained, which would be more uniform at different times; but a trial soon showed that method to be impracticable unless modified by adding other parts to the shutter and so increasing its cost, its liability to derangement, and its weight. The writer finds that by the simple hand method with his shutter, when the cord is coiled on the cylinder in the direction in which a clock's hands move, he could not produce a revolution which should occupy more than $\frac{1}{4}$ second, and unless violence were used, or a decided jerk given, the revolution could not be accomplished in much less time. Probably, indeed, this quarter of a second cannot be varied by more than $\frac{1}{20}$ second without knowing it, although the experiments are done at different times; and with ordinary care and a little practice this amount of variation may almost certainly be considerably reduced.

In this particular shutter, therefore, the figures marked on it must be multiplied by 4 to give the fractions of a second indicating the duration of exposure, and $\frac{1}{16}$ second is the longest exposure practicable by this method. $\frac{1}{16}$ second is perhaps the longest exposure required for ordinary instantaneous work, but this may be doubled, or otherwise increased, with a fair amount of accuracy by putting the string from *f over* the cylinder, and so drawing the wheel round. The reason of this decrease in rapidity of revolution is obvious, for when at rest the weight *h* is downwards, and the opening in *d* on the right-hand side, so that when the wheel moves as first described, the orifice has farther to go before it gets to the lens than when moving in the other direction; in the former case, also, the weight precedes the opening, while in the latter case it follows it.

With the shutter and lens as above described, the length of the opening on the revolving piece is about 3 times the diameter of the full aperture of the lens, a point which is held by some to be very important; when the opening is reduced to $\frac{1}{6}$ of the circumference, it is still equal to twice the lens aperture; and not until reduced to below $\frac{1}{12}$ (exposure then equals $\frac{1}{48}$ second) is the aperture of the shutter narrower than the diameter of the lens.

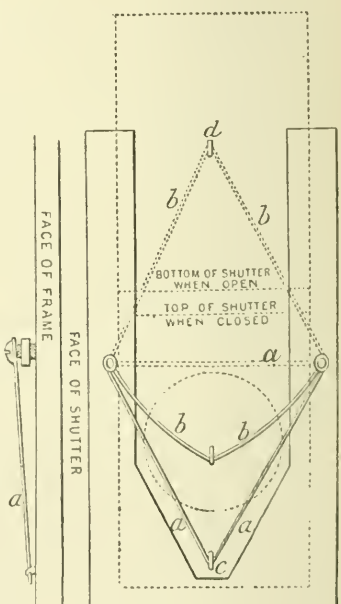
The method of timing the revolution of the wheel of such a shutter is very simple. A tuning-fork has a pin bent

round the end of one of its prongs, so that the point projects at right angles to the plane of vibration of the fork. It may be sufficiently fixed by binding it on with cotton. By fastening this to the string, or merely holding them together, and drawing the pin point across a smoked glass plate (while the fork vibrates) at the rate which is to be determined, the wavy line on the plate will accurately show the number of vibrations the fork has made during its movement. The string should be drawn so that the wheel stops with its opening diametrically opposite the lens opening, for if carried out as above described, the wheel will make a fraction more than one complete revolution.

Then measure off from the end of the wavy line a length equal to the circumference of the cylinder *e*, and count the humps along one side of the measured piece of line. This number, divided into 430 if the fork is an A fork, as used for tuning violins, or into 256, if it is a C fork, will give the fraction of a second occupied by the revolution. The writer, in using an A fork, got numbers such as 107, 111, and so on, which are sensibly a quarter of 430; the time, therefore, was ¼ second. (H. Chapman Jones.)

The Jarvis Shutter.—Various devices have been employed to enable an instantaneous shutter to give a longer exposure to the foreground than to the sky. Most of them, however, are more or less complicated and expensive, and nearly all the devices with which the writer is acquainted are patented. The shutter which forms the subject of Fig. 236 is free from all the above objections. It is the invention of Mr. Jarvis, a Chicago amateur, is extremely simple in construction and action, easily made by any one with any "tinkering" propensities, and is very light and compact. As shown in the sketch, it consists of a vertical slide working in a frame in the usual manner, the frame being provided with a stop at the bottom to arrest the slide at the lowest or "closed" position. The back of the frame is solid, except where cut out to fit lens mount, as shown by dotted circle. The front is open, being merely provided with guide strips for the edges of slide. This slide must be made of some light material—wood or ebonite being preferable. A

FIG. 236.



small screw-eye is inserted at *d*, while a pin, slightly bent downwards, is put in at *c*. A rubber band *a* is hooked under the latter, while another one *b*, is passed through the former. Both these bands are screwed by their ends to the sides of the frame by screws as shown. The band *a* should be just "taut" when horizontal; *b* must be a little slack when the shutter is closed. The full lines in the sketch show both bands in the position they occupy when the shutter is at its lowest position, while the dotted lines show them at its highest point. A trigger is provided for releasing the shutter, but it was not

considered necessary to show that, as there is nothing peculiar about it; a pneumatic attachment can be used if preferred. The action of the shutter is as follows:—The slide being in its lowest position, is held in place by the trigger, while the band *a* is hooked under pin *c*. On releasing the trigger, this rubber band causes the slide to fly up, and gives it sufficient impetus to carry it far beyond the travel of the band itself; this impetus is exhausted in stretching the band *b*, and, in recoiling, this latter drives the shutter "home" again. As the band *a* is, when released, somewhat in front of the end of pin *c* (see side view), the latter does not touch it in its descent. (F. H. Davies.)

Making Photographic Exposures in the Dark Room.—With the introduction of bromo-argentic gelatine paper for copying and printing purposes, improved devices have been required for making short and rapid exposures. Several plans suggested themselves, but the one which is herewith described was that which was adopted as being both rapid and simple. On working a large number of gelatine prints, it was important that there should be no delay, as might be occasioned by the necessity of opening the dark-room door for the purpose of making exposures to actinic light. This device is constructed to avoid the difficulty, and with it exposures can be made while the development of other pictures is going on in the dark room.

Fig. 237 represents a side elevation; Fig. 238, a front elevation; Fig. 239, the device adapted for use by artificial light.

b is a permanent wood frame set obliquely in, and forming part of, the non-actinic light sash frame, which is set just behind the outer sash.

a is a cotton blind or curtain of double thickness, painted a non-actinic colour—such as a deep orange ruby, or it may be black—which is open at the bottom, having its ends secured by narrow strips (as shown in Fig. 238) to an ordinary spring roller; *c d* is a metal wire guide which holds the curtain light-tight against the frame *b*. The top of the curtain is kept flat and straight by the usual blind stick.

FIG. 237

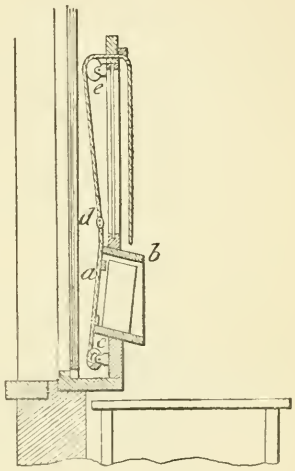
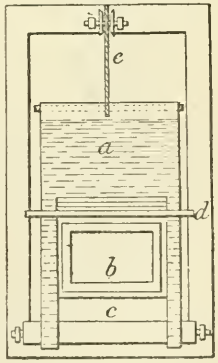


FIG. 238.



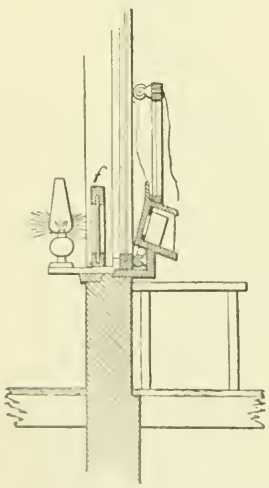
A cord *e*, secured by a screw-eye to the blind stick, runs up over a pulley, through a hole in the sash frame to the inside of the dark room. A knot made in the cord at the right point prevents

the curtain from going down too far, and holds it in the position shown in Fig. 237.

The operation is simple, the printing frame being inserted in the frame *b*, making a close fit, as shown in Fig. 237, the glass side being towards curtain *a*.

The cord *e* is pulled down quickly in the dark room, which brings the open portion of the blind *a* in front of the frame, exposing the latter to actinic light, which enters through the outer sash. Upon releasing the cord *e*, the spring roller *c* and the force of gravity pull the blind *a* rapidly back. The exposure can be made in a second, and sometimes shorter.

FIG. 239.



On Fig. 239 is shown the same construction, except that in place of diffused daylight is substituted an oil lamp, between which and the blind is located a sheet of ground glass *f*. Such an arrangement is useful in making transparencies at night, as the same light will partially light the dark room and furnish light for the exposures. Different sized kits may be made to fit the frame *b*, and thus accommodate different printing frames.

A table or shelf is conveniently arranged in front of the window, which permits the printing frame to be easily handled. The device has been in practical use for a long period of time, and has never become deranged. Its efficiency has been proved. (F. C. Beach).

Dry-plate Holder and Exposing Case.—The amateur photographer in the early stages of his career has perhaps spoiled a large percentage of his plates by fogging—sometimes due to carelessness, but more frequently to a want of knowledge regarding the capabilities of his apparatus.

The camera, with the plate holder attached, is presumed to be light-tight, but very often is not. The 2 weak points are the sliding front and the junction of the holder with the camera. By holding it up to direct sunlight, and alternately looking in from front and rear, any defect will be detected.

The ordinary double plate holder is perfectly safe when at rest, but as soon as the slide is put in motion it is not light-proof, from the very nature of its construction. Any one will readily be convinced on this point by drawing the slide in full sunlight.

As most of the work of the amateur is done out of doors, in light where a negative may be made in the fraction of a second, every possible precaution must be taken to prevent fog.

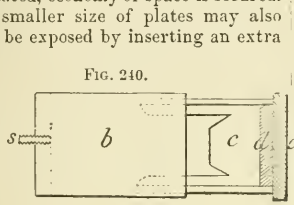
Nearly 2 years since it occurred to me that a more certain and convenient method of exposing a dry plate could be devised, and a rough model was then constructed similar to that about to be described.

The plate holder (Fig. 240), shown partially open, consists of a rectangular box *b*, made of cardboard, tin, or brass, preferably the former. In the bottom of the box is glued a strip of wood $\frac{1}{8}$ in. in width, in which is inserted a small machine screw *s*, which projects outside about $\frac{1}{4}$ in. The carrier *c*, for holding the plate, is made of one piece of tin, with flanges on the sides, the middle

being cut out in order to form a spring, which brings the film side of the plate always in the same position as in an ordinary holder. By making the carrier as indicated, economy of space is secured.

The smaller size of plates may also readily be exposed by inserting an extra

FIG. 240.



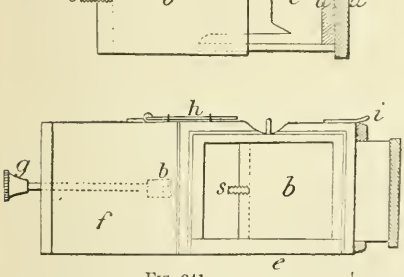


FIG. 241.

carrier made of tintype, the plate being held in the middle of the field. This method of holding small plates was designed by S. W. Burnham, and is an important feature, as for a good deal of experimental work they answer the purpose of full size plates.

The case is especially adapted for outdoor work, and will probably answer for plates as large as 8 by 10 without any modification.

The carrier *c* is attached to a rectangular block of wood *a*, by allowing projections in either end to pass through, when they are bent down and clinched. The block *a* projects above the mouth of the box *b*, forming a light-breaker; an additional security is also obtained by the strip of wood *d*, which enters the mouth of the box when closed.

For a 4 by 5 plate, the dimensions of the plate holder are as follows: length, $6\frac{3}{4}$ in.; width, $4\frac{1}{4}$ in.; thickness, $\frac{1}{4}$ in. When the cover *b* is made of tin instead of cardboard, the thickness is only $\frac{3}{16}$ in., the other dimensions remaining the same.

One dozen of these cases, holding 4 by 5 plates, are easily carried in one's pocket. To prevent accident, they may be kept securely closed by a rubber band. Burnham, however, has invented a very neat lock, which is entirely automatic in its action, being opened and closed in the act of exposing the plate. It consists of a tongue of spring brass attached to the under side of the cover *b*, which enters a pin set in the middle of the block *a*.

The exposing case (Fig. 241) is a rectangular box, *e f*, made in 2 parts for convenience, being hinged near the middle so that it can be readily doubled up to render it more portable. It is rigidly held in the position shown in the sketch by means of a long hinge *h*, on the top of it, and is attached to the camera in the same manner as a double plate holder. In order to secure greater security against the entrance of light, an outside flange is added where it joins the camera. At the left-hand side is a hinged door *i*, through which the plate holder is inserted.

In the cut a plate holder is shown partially in the case. In the dark chamber *f*, is inserted a draw rod *g*, terminating in a mill-head on the outside, and having a cylindrical nut *k* inside for securing the screw *s*.

To make an exposure, proceed as follows:—

The door *i* is opened and a plate holder inserted. When the door is closed, the rod *g* is pushed in to meet the screw *s*, one or two turns being sufficient to secure it. It is then drawn out as far as it will go; removing the cover *b* to the chamber *f*, leaving the carrier *c* holding the plate in the camera ready for exposure.

The rear end of carrier *c* is held in position by the block *a*, accurately fitting the case and the front end is supported by the cover *b*, which is not entirely removed.

After the exposure has been made, the door *i* is opened, the rod *g* is unscrewed, and the plate holder is pushed out by pushing in the rod *g*, which is made long enough for that purpose.

The cover *b* is drawn as easily as a slide, and since in the act of drawing it is constantly in a dark chamber, it is not necessary to cover the holder with a cloth, and an exposure may be made in the sun without danger of fog.

The distinctive feature of this method consists, first, in having a compact and light-proof case for carrying the plate; second, in drawing the cover (instead of a slide) in a dark chamber. By this plan all danger of fog in making an exposure is entirely obviated.

The cardboard holders are inexpensive, and it is easier to carry a dozen plates in them than 3 double holders of the usual pattern.

It is adapted for cameras already in use, though in the construction of new ones it may form part of the camera itself; the dark chamber *f* being hinged for convenience in transportation.

In using this apparatus, it would be more convenient if the ground glass focussing screen could be dispensed with, so as to leave the case constantly attached to the camera during an expedition. This may be accomplished in various ways.

(1) By fixing the ground glass in the back of the exposing case.

(2) By a movable ground glass in the back of the exposing case, which may readily be brought in the plane of the plate.

(3) By putting the ground glass in a regular carrier and inserting it the same as a plate.

In either case it is necessary to cut a hole in the back of the exposing case and cover it with a door or slide.

Burnham has designed a very satisfactory piece of mechanism for the second method, but it necessarily makes the apparatus more complicated. The third was the suggestion of Prof. H. D. Garrison.

The first and third method work well, without seriously affecting the simplicity of the apparatus. When the ground glass is fixed, however, in the back of the case, it is not in focus for the plate, and it is necessary to make an adjustment after focussing. This is not a serious objection, however, as every amateur will soon learn to mark his focus for infinite distance, at which mark $\frac{9}{10}$ of all his outdoor pictures must be taken. (Prof. G. W. Hough.)

Camera Attachment for Paper Negatives.—In computing the weight of the various items for a photographic tour, the glass almost invariably comes out at the head of the list, and the farther or longer the journey, so much more does the weight of the plates stand out pre-eminent; indeed, if one goes out on a trip with only 3 doz. half-plates, the glass will probably weigh nearly as much as camera, backs, and tripod, in spite of the stipulation with the maker to supply plates on "thin glass."

Next in importance to glass as a support comes paper, and it is quite easy to understand that the tourist in out-of-the-way parts might be able to take an apparatus containing a roll of sensitive paper, when it would be altogether impracticable for him to take an equivalent surface of coated glass, and in such a case the roller slide becomes of especial value.

The roller slide of Melhuish is tolerably well known, and is, we believe, now obtainable as an article of commerce. The slide is fitted up with 2 rollers, and the sensitive sheets are gummed together, making one long band, the ends of which are gummed to pieces of paper always kept on the rollers. The sensitive sheets are wound off the left or reserve roller on to the right or exposed roller, until all are exposed.

The rollers are supported on springs, to render their motion equal; they are turned by milled heads, and clamped when each fresh sheet is brought into position by nuts; a board is pressed forward by springs so as to hold the sheet to be exposed, and keep it smooth against the plate of glass; when the sheet has been exposed, the board is drawn back from the glass in order to release the exposed sheet, and allow it to be rolled on the exposed roller; the board is kept back while this is being done by turning a square rod half round, so that the angles of the square will not

pass back through the square opening until again turned opposite to it; by opening doors the operator can see (through the yellow glass) to adjust the position of the sensitive sheets when changing them.

The remarkable similarity of such a slide to an automatic printing frame will strike the reader; and, like the printing frame, it possesses the advantage of speed in working—no small consideration to the photographer in a distant, and possibly hostile, country.

Fine paper, well sized with an insoluble size and coated with a sensitive emulsion, is, we believe, the very best material to use in the roller slide; and such a paper might be made in long lengths at a very low price, a coating machine similar to that constructed for use in making carbon tissue being employed. We have used such paper with success, and hope that some manufacturer will introduce it into commerce before long. But the question suggests itself, how are the paper negatives to be rendered transparent, and how is the grain of the paper to be obliterated? Simply by pressure, as extremely heavy rolling will render such paper almost as transparent as glass, a fact abundantly demonstrated by Woodbury in his experiments on the Photo-Filigrane process, and confirmed by some trials which we have made.

It must be confessed that roller slide experiments which we have made with sensitive films supported on gelatine sheets, or on such composite sheets as the alternate rubber and collodion pellicle of Warnerke, have been hardly satisfactory—possibly, however, from our own want of skill; while no form of the Calotype process which we have tried has proved so satisfactory as gelatino-bromide paper. (*Photo. News.*)

Apparatus for Instantaneous Photography.—With ordinary photographic apparatus, it is necessary to begin by focussing upon the object that one desires to photograph, and to afterwards remove the ground glass and substitute for it a frame containing the sensitised plate. After this, the latter is uncovered and the cap is taken from the objective. It goes without saying that if the object to be photographed were an animal in motion, it would have been out of sight long before everything was arranged to take its image upon the sensitised plate. This difficulty has been surmounted in 3 ways. One consists in the use of objectives that give an equal sharpness with objects situated in very different planes, and that do not require focussing. The second way of getting round the difficulty is that adopted by Muybridge and Marey, and consists in setting up the apparatus in advance, focussing it upon a certain point, and then causing the animal to pass before it.

The third method is one whose principle was made known some time ago, and which consists in using a very portable apparatus formed of 2 symmetrical and interdependent chambers, with a pair of identical objectives, one of which serves for focussing and the other for obtaining the image.

The majority of the apparatus of this kind that have hitherto been invented give exceedingly small images, that are of not much practical account.

Prof. Hermann Fol has invented an apparatus on this principle which is a great improvement upon all other portable devices of the kind in use, and which he terms a "photographic repeating gun." This is placed against the shoulder like an ordinary rifle, and is thus given sufficient stability to make the images very sharp. The image, although it utilises only the central part of what the objective is capable of covering, measures $3\frac{1}{2}$ by 5 in. The apparatus contains 11 plates, which may be successively exposed within short intervals, without any other manipulation than that of raising the shutter and inclining the whole thing alternately in one direction and the other. Finally, it folds up in such a way as to make it convenient for carriage.

The objectives are Steinheil's "anti-planets," 1 in. in diameter, of 6-in. focus, and capable of covering a plate $12\frac{1}{2}$ in. square. Their luminous power is considerable.

The shutter is a spring one, operated pneumatically, and consists of 2 metallic discs, each containing an aperture and passing in opposite directions between the 2 sets of lenses of the objective at the place where the diaphragm is usually situated. It gives exposures that may be varied at will from $\frac{1}{80}$ to $\frac{1}{120}$ of a second.

The camera is divided into 2 spaces by a partition (Fig. 242, S) which is light-proof. The folding sides of the

FIG. 244.

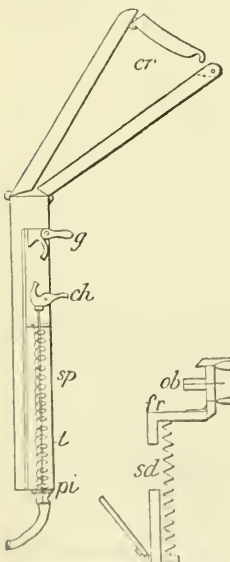
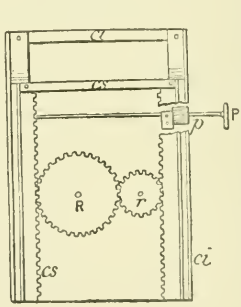


FIG. 243.



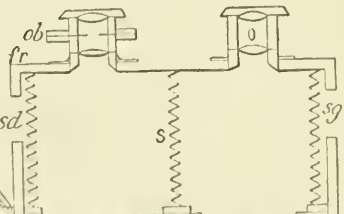


FIG. 242.

camera are formed of strips of cardboard, one thickness of black taffety, and kid skin. The right side (Fig. 242, *sq*) forms a chamber which is designed to allow the objective to the left *o* to form an image upon the ground glass *gl*. The left side *sd* circumscribes the space in which the objective that carries the shutter *ob* forms an image upon a sensitised plate contained in the box B.

The 2 objectives are carried by a wooden front *fr*. A large frame *c* carries the ground glass and plate box, and, at the same time, serves as a point of attachment for the folding sides. Adjustment is effected by moving the front *f* toward or away from the frame *c* by a mechanism that is described farther on. The plate box is sufficiently spacious to hold 12 plates in 2 piles of 6 each. Each plate is fixed in a small wooden frame, provided at the back with a very thin piece of sheet iron, which intercepts the light between it and the following one.

The 2 piles of frames are separated from each other by an incomplete partition that leaves enough space here and there for one of the frames to slide from one pile to the other. If, then, this 12-frame box contains but 11 frames, an empty space remains, and it will always be possible, by inclining the box, to cause the eleventh frame to slide from one pile to the other. When a plate has been exposed, it is therefore only necessary to incline the apparatus toward the right to cause the plate to enter the compartment situated on that side. If, now, the apparatus be pointed so that the objectives face the ground, and afterward be inclined to the left, one of the plates to the right will slide on to the pile to the left. Before each exposure it is well to tighten the screw *r* a little, in order to apply the foremost frame against the end of the box and give it exactly the same distance from

the objective that the ground glass has. By repeating the same motions the 11 plates will be exposed in succession without any confusion being possible, and without there being any necessity of opening the box, or of allowing light to pass at any other moment than that of the exposure.

When the exposure is at an end, a metallic plate is pushed, and this separates the interior of the plate box from the chamber to the right. The box, being now closed on all sides, may be removed and placed entirely in the frame *c*, which is closed by a small door. When the front end is applied to the frame, the entire apparatus is reduced to a box, $5 \times 6\frac{1}{2} \times 10$ in. in dimensions.

The focussing is effected by 2 metallic frames provided with racks (Fig. 243) that are placed beneath the apparatus —one of them carrying a front piece, *ci*, and the other, *cs*, sliding in a groove in the frame. These two frames are set in motion, one over the other, by a lateral button P, at the end of a rod that carries 2 grooved cylinders *p*. These grooves engage with the rack of the lateral pieces of the metallic frame *ci*. The frame *cs* is set in motion by a horizontal wheel R, which has a vertical axle that terminates beneath in a knob which is held in the left hand and serves to support the apparatus. It is only necessary to slightly turn the palm of this hand in one direction or the other to bring about a rapid motion of the frame *cs*, and consequently of the entire front end with the objectives, through the intermedium of the large wheel R (Fig. 243). A small wheel *r* serves for transmitting the motion of the large one to the opposite side of the frame, and to give it a parallel sliding motion free from any lateral displacement.

When in use the apparatus is affixed to a frame (Fig. 244) which is like a gun-stock in form, but which consists of four hinged pieces that permit of its being folded up. The front part contains a tube (Fig. 244, *t*) in which slides a piston *pi*, actuated by a spiral spring *sp*. This spring, upon uncoiling, drives the piston suddenly forward and produces a compression of the air which is transmitted, through the rubber tube *ca*, to the shutter, and unfastens it. In order to tighten the spring up it is only necessary to draw back the piece *ch*, until it hooks itself to the trigger *g*. A pressure of the finger upon the latter is sufficient to set the shutter free.

The mode of using the apparatus is as follows: The plate box being inserted, the shutter raised, the stock placed against the shoulder, and the spring tightened, it suffices to turn the apparatus toward the object to be photographed, and to examine its image upon the ground glass. A slight movement of the left hand effects the focussing, while the index of the right hand determines the amount of exposure. It is only necessary, then, to incline the apparatus successively in 2 directions to cause another sensitised plate to succeed the one that has just been exposed; and, when the spring has again been tautened, one can proceed to another exposure.

With the plates now in market, there may be obtained in open air, in fine weather, in summer and in the middle of the day, very excellent negatives. Under other circumstances, such rapid exposures are insufficient to impress the plate to the desired degree for a good negative.

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